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THE

MINERAL WEALTH OF VIRGINIA

TRIBUTARY TO THE LINES OF THE

Norfolk and Western and Shenandoah Valley

RAILROAD COMPANIES.

BY

ANDREW S. McCREATH,

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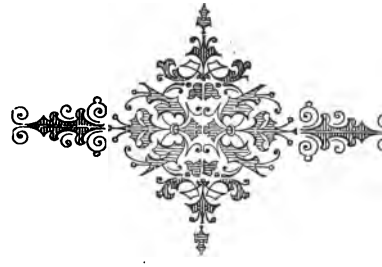

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PREFACE.

The early months of 1882 opened a new era in the economic history of the South by the combinations resulting from the transfer of ownership of the Atlantic, Mississippi and Ohio railway to the Norfolk and Western Company, its new associations arising from the completion of the Shenandoah Valley railway to its junction at Roanoke, and the operating arrangements then effected by contracts between these lines and their southern connections for the creation of the new direct trunk route between the North and South, known as the Virginia, Tennessee and Georgia Air-Line.

The country traversed by this system had long been known to be rich in minerals, in fact supposed to be richer than any other portion of the Union; but though this section had been productive in coal, iron, lead, zinc and copper from the early Colonial times, and its iron and lead had furnished material sinews of war in the campaigns of the Revolution, as well as in the later stirring struggles of the Confederate States, the construction of mineral branches to develop these industries had not been inaugurated, nor sufficient encouragement given to the local traffic of the line—that vital element to the permanent prosperity of any railway system.

The new management took hold resolved to make every mile pay its quota to the general revenue, and to develop every source of income, in coal, iron, woods, cattle and miscellaneous business.

Considerable traffic was already established; iron in particular was an important element. Some twenty small furnaces of from five to ten tons' daily capacity were in operation, producing a superior quality of cold-blast charcoal iron in wide demand for the manufacture of car-wheels, but

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retarded in extension by the gradual diminution of fuel supply and by distance from railway communications. The first necessity was cheap fuel, and this was met by the construction of the New River branch of the Norfolk and Western (seventy-five miles) into the Flat Top district, and the opening of the coal fields there for an almost unlimited supply of the finest qualities of coal and coke.

The railways were prepared for heavy mineral traffic; with well-ballasted road beds, steel rails, and substantial structures, and the equipment throughout of the best quality.

Exact and reliable knowledge of the probable amount, quality, and value of the sources of traffic became a necessity, and at an early day received the attention of the new management.

Upon consultation with many of the leading Iron Masters of Pennsylvania, Mr. Andrew S. McCreath, chemist to the State Geological Survey of Pennsylvania, was recommended as an eminently capable, trustworthy, and conservative person to examine, sample, and analyze the various mineral developments tributary to the lines, and prepare a report upon their commercial values.

The original instructions issued were to examine and report on developed properties only; but the actual field of labor gradually extended until a much wider scope and area were included.

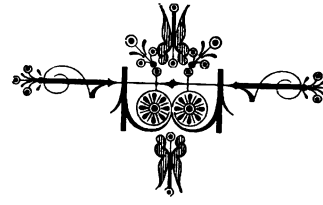
Positive knowledge as a basis for estimates of future mineral traffic being the main object of the management, the instructions were to report on everything good, bad and indifferent, just as found, and the field work extended through the months of May, June, July, August and September, 1882, embracing the line of the Shenandoah Valley, the Norfolk and Western, west of Roanoke, and portions of Tennessee tributary to this system. During the fall of 1883 and the spring of 1884, additional work has been done, and two months have been spent in a more detailed examination of the Cripple Creek iron region and the Flat-Top coal-field. The results will be found embodied in the accompanying pages.

The object of this report is simply to furnish reliable information to all persons inquiring into the resources and condition of the territory tributary to the railways.

It is unnecessary to remark upon the care and labor given to this examination, or the entirely conservative character of the information now furnished. This has been satisfactory to the Companies, and is presented to the public with their indorsement.

FREDERICK J. KIMBALL,
President Norfolk and Western and Shenandoah Valley Railroad Companies.

PHILADELPHIA, *1884.*



LETTER TRANSMITTING REPORT.

HARRISBURG, PA., *July 1st, 1884.*

F. J. KIMBALL, Esq., *President Norfolk and Western and Shenandoah Valley Railroad Companies, 333 Walnut Street, Philadelphia, Pa.:*

DEAR SIR: I herewith submit my second and enlarged report on the mineral wealth of Virginia tributary to your railroads.

Since the preparation and publication of my first report there has been so much development of mineral deposits along the line of your roads as to render it desirable that I should reëxamine numerous places and bring the report upon them up to date; but especially the completion of the New River Division of the Norfolk and Western Railroad into and through the Flat Top coal field and the building of your Cripple Creek extension rendered it necessary that I should make a new and complete report in considerable detail upon the coal and coke of the Flat Top coal field and a similar report on the Cripple Creek and New River iron ores. These new reports are made in conjunction with Franklin Platt, of Philadelphia, and we are equally and jointly responsible, therefore, for the facts stated and the conclusions drawn therefrom in these reports.

At many of the points visited I have not thought it necessary or even desirable to re-describe the iron ore openings inasmuch as the open banks present only such ordinary variations as are constantly occurring in such deposits.

At other points I have found it desirable to add much new material representing openings made since my last examination, and this has necessitated a partial re-writing of the report.

The more extended development which has been made

since my first report was published, has only tended to strengthen and confirm the favorable opinion therein expressed as to the future prospects for the profitable development of the mineral wealth of the regions tributary to your railroad system.

It may be proper to add that every sample taken for analysis was carefully selected to obtain, as far as possible, a fair average, and that every analysis made has been included in the body of the report.

Yours truly,

ANDREW S. McCREATH.

TABLE OF CONTENTS.

		Page.
1.	Preface by President F. J. Kimball, ...	iii–v
2.	Letter transmitting Report by A. S. McCreath,	vii & viii
3.	Introduction, giving description of railroad lines and geology, &c., ...	1–17
4.	Chapter I. Iron and Manganese Ores, ...	17–101
	Section I. Mines along the Shenandoah Valley Railroad, ...	17–56
	Section II. Mines along the main line of the Norfolk and Western Railroad, ...	56–61
	Section III. Ores tributary to the New River Division of the Norfolk and Western Railroad,	61–65
	Section IV. Red Hematite and Magnetic Iron Ores in the Lower Silurian Limestones in South-West Virginia and Tennessee tributary to the Norfolk and Western Railroad system,	65–73
	Section V. Mines along the Cripple Creek Extension, ...	74–99
	Section VI. Miscellaneous Iron Ores in Montgomery, Craig, and Bland Counties, ...	99–101
5.	Chapter II. Zinc and Lead Ores, ...	101–103
6.	Chapter III. Gypsum, (Plaster,)	104 & 105
7.	Chapter IV. Coal and Coke, ...	105–131
	Section I. Flat Top Coal Field, ...	105–129
	Section II. Coals in the Measures underlying the Carboniferous system proper, ...	129–131
8.	Chapter V. Miscellaneous Minerals, ...	131–134
9.	Chapter VI. Summary of Results and Conclusions, ...	134–143

THE MINERAL WEALTH OF VIRGINIA.

The Shenandoah Valley Railroad has its northern terminus at Hagerstown, Maryland, where it makes direct connection with the Pennsylvania Railroad system by means of the Cumberland Valley Railroad, and with Baltimore by means of the Western Maryland Railroad; and its southern terminus at Roanoke, Virginia, where it joins the Norfolk and Western Railroad, the entire length of the line being two hundred and forty miles. It runs along the floor of the Great Valley in a general south by west and southwest direction, following closely the great iron ore belt along the western slope of the Blue Ridge.

At Shepherdstown, West Virginia, seventeen miles from Hagerstown, it crosses the Potomac river, and at Shenandoah Junction it crosses the main line of the Baltimore and Ohio Railroad ninety miles west from Baltimore. Five miles further, at Charleston, it crosses the Valley Branch of the Baltimore and Ohio Railway, and at Riverton it crosses the line of the Manassas Branch of the Virginia Midland and also the Shenandoah river just below the confluence of its North and South Forks. Eighty-nine miles south from Hagerstown it reaches Luray, near which are the famous caverns of that name which are now attracting so much attention on account of their wonderful beauty and grandeur.

At Waynesboro' Junction it connects with the Chesapeake and Ohio Railway, twelve miles east of Staunton and one hundred and forty-three miles south from Hagerstown. The Lexington Branch of the Richmond and Allegheny joins it at Loch Laird; and thirteen miles further south at Glenwood, two miles from the Natural Bridge, it crosses the main line of the Richmond and Allegheny Railroad, one hundred and ninety-nine miles from Hagerstown; and

forty-one miles still further it reaches its terminus at Roanoke, fifty-four miles west from Lynchburg.

The Norfolk and Western main line extends from Norfolk, Virginia, at the mouth of the Chesapeake Bay, to Bristol, Tennessee, where it connects with the East Tennessee, Virginia and Georgia Railroad, the distance being four hundred and eight miles. At Lynchburg it makes connection with the Virginia Midland Railroad.

The New River Division of the Norfolk and Western is seventy-five miles long; starting at Central and having its present terminus at Pocahontas in the great Flat Top coal region, with its vast stores of the very best of coal suitable alike for steam purposes and for the production of a first-class coke for blast furnace use.

The Flat Top Extension of the New River Division, from the mouth of Laurel creek down the Bluestone river and up Crane creek to Peter's Gap, is now being built to develop the great coal field which lies on the waters tributary to the Bluestone. There is also in contemplation a further extension of this line from Peter's Gap, on Flat Top mountain, down the Pinnacle Fork of the Guyandotte river to Rock Castle; from that point diverging in a *northerly* direction connecting with the Ohio Central Railroad at St. Albans—thus giving a connection into Wheeling and Pittsburgh; also diverging in a *north-westerly* direction from Rock Castle, so as to reach Catlettsburg, Ashland and Ironton, and thus enabling the ores from the Cripple Creek region and the coke from the Flat Top coal field to be delivered to the iron manufacturing establishments along the Ohio river. Surveys are now being made for these lines, but they are not yet definitely located. On any location which may be chosen, this proposed railroad line will pass through Coal Measures for practically the entire distance from the crest of the Flat Top mountain to the Ohio river. The detailed description showing the thickness, character and availability of the coal beds of this region will be embodied in a separate report.

The Cripple Creek Extension leaves the Norfolk and Western Railroad at the town of Pulaski, and goes almost due south nine miles to New River. Here it crosses the

river and then follows its south or east bank for eighteen miles, when it re-crosses to the north side and follows this three miles further to Ivanhoe furnace (Van Liew's.) It then cuts across the country for three miles, when it strikes Cripple Creek and follows the Valley of this stream to Speedwell furnace, the entire present length of the line being forty-seven miles.

So varied are the geological features of the country traversed by your several lines of railroad, that every important geological formation known to be in North America can be reached within easy distance; and it follows as a necessary consequence that all the different minerals found in the various formations should be tributary to your railroad system.

The varied character of the minerals, their great abundance and superior quality, taken into consideration along with the other natural advantages—such as ready facilities for mining, abundance of water supply, numerous outlets to markets in every direction—should result in the establishment of many industrial enterprises along the lines of your railroad.

Nor should it be forgotten that your railroad system forms an important link in the great chain of railroads which makes a direct route from New York to New Orleans, traversing the Great Limestone Valley for hundreds of miles—the same valley which in Pennsylvania and elsewhere, owing to the peculiar productiveness of the soil, has been a source of great agricultural wealth. And here a brief description of the Great Valley, its geological formations and mineral resources, will be in place.

From the Hudson River at Newburg to the Tennessee River at and beyond Chattanooga, a great limestone valley traverses in an unbroken line the States of New York, New Jersey, Pennsylvania, Maryland, Virginia and Tennessee.

This valley is a natural highway between the Northern and Southern States, and has been occupied by successive lines of railway, forming a continuous inland route between New York and New Orleans. It is therefore known as the Great Valley; but it has many local names. In New York

State it is called the Walkill Valley ; in Eastern Pennsylvania, the Kittatinny Valley ; in Middle Pennsylvania, the Lebanon or Cumberland Valley ; in Virginia, the Shenandoah or Winchester Valley ; and further south, the Valley of East Tennessee.

Newburg, Easton, Bethlehem, Allentown, Reading, Lebanon, Harrisburg, Carlisle, Chambersburg, Martinsburg. Staunton, Winchester, Christiansburg, Wytheville, Abingdon, Bristol, Knoxville and Chattanooga are all flourishing towns or cities of this Great Valley.

The Hudson, Delaware, Lehigh, Schuylkill, Susquehanna, Potomac, James and other Virginia rivers flow across it from north to south, or from north-west to south-east. The New River in Virginia and the numerous branches of the Tennessee river flow across it from south to north, or from south-east to north-west.

Large streams like the Swatara, the Conedoguinet, the Conococheague and the Shenandoah flow along its floor lengthwise, being fed by their branches descending from the mountains on each side.

Two ranges of mountains hem the valley in. The range on the south-east is called the South Mountains in Pennsylvania ; the Blue Ridge, with its south-west prolongations Poplar Camp and Iron Mountain, in Virginia ; the Smoky Mountains in Tennessee ; but many local names are also given to this wall of the valley which cuts it off from the tide-water country. The Peaks of Otter, west of Lynchburg, are on this range.

The north-western wall of the valley is usually called the North Mountain, and is the first of the belt of the Allegheny Mountains ; but it has such local names as Shawangunk, Kittatinny, Blue and Brushy Mountain.

These two mountain walls are of entirely different character—of different heights, breadths, shapes, geological age, rock structure and mineral value.

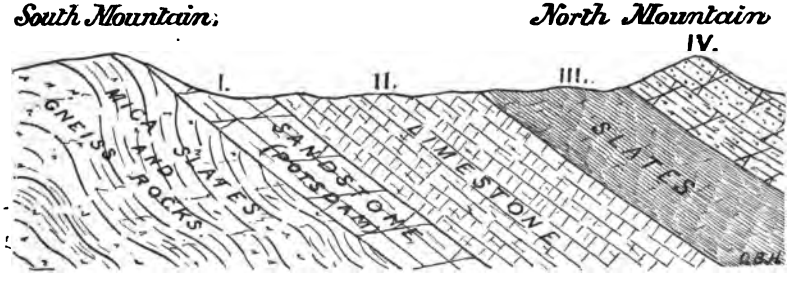
The South Mountain (or Blue Ridge) is a wide range of rounded summits, high knobs, and irregular valleys with numerous ravines ; while the North Mountain is always a single sharp narrow ridge, everywhere of about the same

elevation, and broken at long intervals by transverse cuts or water gaps.

The rocks of the South Mountain are much older than those of the valley, and dip northward underneath the rocks of the valley ; whereas the rocks of the North Mountain are younger than those of the valley and overlie them in regular geological order.

The valley itself varies in width from ten to twenty miles, and its floor is composed of two different kinds of rock, limestone and slates ; separated from each other by an irregular line running along the middle of the valley, its whole length ; the limestone land stretching to the foot of the South Mountain, and the slate land stretching to the foot and up the slope of the North Mountain ; the limestone rocks passing down underneath the slate rocks, northward.

An *ideal* section of the valley, looking south-west, may be represented thus :—

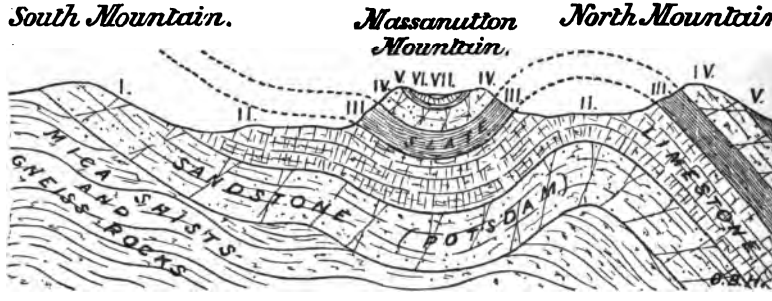


An *actual* section of the valley, however, at any one place along the whole line, has not by any means this simple character ; for the four formations, numbers I, II, III, and IV instead of descending regularly beneath each other in one long slope are crushed into numerous folds, most of them small, but some of them large. The upward folds (anticlinal) form arches of rock running lengthwise of the valley ; the downward folds (synclinal) make troughs ; and some of these troughs are so broad and deep that the upper formations have been preserved in them in the middle of the valley.

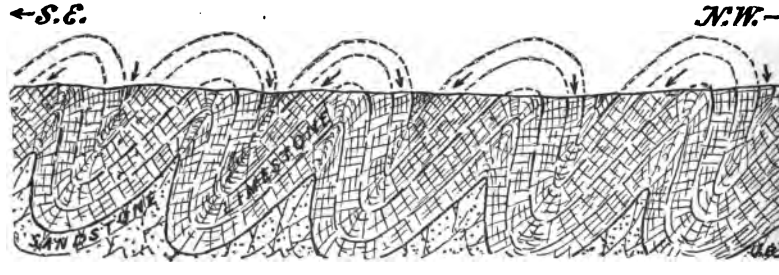
Massanutton Mountain is an example of this. It runs for miles along the middle of the valley, dividing it into

two valleys; along one of these flows the Shenandoah river, and along the other the Little Shenandoah river.

Here an *ideal* section of the valley may be represented thus:

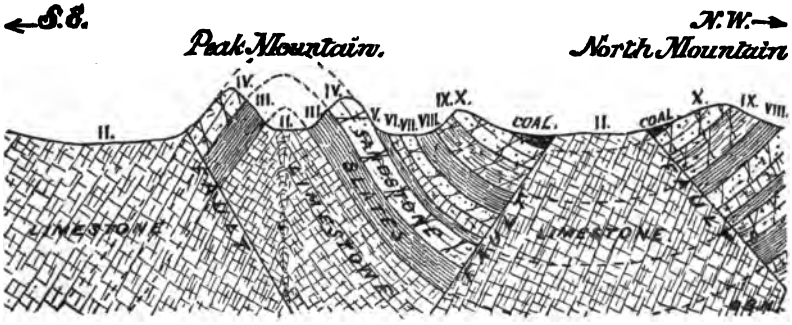


Besides this kind of disturbance of the regularity of the geology of the valley there is another of a still more important character:—the pressure from the south-east has thrown the folds over towards the north-west, and *overturned* many of the strata, so that they dip the wrong way, viz: south-east instead of dipping regularly north-west; and this is especially true of the limestone strata; so that at the surface of the ground they seem *all* to dip south-east, thus:—



Besides this there is a third kind of disturbance which changes the character of the valley very much in its passage down south, *i. e.*, in middle and southern Virginia and Tennessee, viz: *breaks*, or *upthrow faults* along the anticlinal folds.

An *ideal* section through Peak Mountain, just beyond the New River, will show the character of these faults, thus:—



A fourth kind of disturbance is seen to be in the shape of breaks which run *diagonally* across the valley. The greatest of these is north of Christiansburg, where the railroad line going south ascends about a thousand feet and then continues into Tennessee on a higher level. The whole valley floor south of this great *cross fault* is elevated above the valley floor north of it towards Staunton. Here the old geographers have supposed the "Allegheny Mountain" to pass over from the north-west to the south-east side of the valley. But it does not. The cross fault makes no change in the general geology of the valley; it only lifts its floor to a higher level to the south-west. The North Mountain (Allegheny Mountain) still keeps on its north-west side and the Blue Ridge keeps on its south-east side; but it is called by different names until it gets into North Carolina.

The above description will suffice for a general understanding of the valley. We will now describe the formations.

The *Blue Ridge or South Mountain rocks* are the oldest, and underlie the whole valley at a great depth, and also underlie all western Virginia and West Virginia and in fact the whole United States to the Rocky Mountains, where they come up and show themselves again; and also in northern New York and Canada.

These *primary rocks* are granitic strata (gneiss) and crystalline slates (mica slate, chlorite slate, garnet slate, etc.) They show no fossils, but contain important beds of iron ore.

The primary rocks appear in all the ravines which descend from the Blue Ridge into the valley, and in all the gaps through the Blue Ridge. They can be studied on the Potomac between Harper's Ferry and Point of Rocks; on the

James, from the Peaks of Otter down to Lynchburg; on the New River, along the North Carolina line; and along French Broad and other rivers which issue from North Carolina into the great valley of East Tennessee.

The ores of this formation are chiefly magnetites and specular iron ores, and they have been extensively developed at different points along the Eastern Blue Ridge:

The Palæozoic formations of the Great Valley lie upon the Primary rocks of the Blue Ridge, and are numbered from I to XIII, but they have names as well as numbers, thus:

XIII.	Coal Measures proper, ...	Carboniferous.
XII.	Conglomerate, ...	
XI.	Umbral Red Shale, ...	
X.	Vespertine Gray Sandstone, . . .	
IX.	Ponent Red Sandstone, ...	Devonian.
VIII.	Vergent Shales, etc., ...	
VII.	Meridial Sandstone, ...	
VI.	Pre-meridial Limestone, ...	Upper Silurian.
V.	Scalent Red Shale and Fossil Ore, . .	
IV.	Levant Sandstone, ...	
III.	Matinal Slates, ...	Lower Silurian.
II.	Matinal Limestone, ...	
I.	Primal Slates and Sandstones. . .	
	Primary rocks of the Blue Ridge, . . . Azoic, (Archean.)	

These names and numbers were given to them by Professor W. B. Rogers, State Geologist of Virginia, and H. D. Rogers, State Geologist of Pennsylvania, in 1840.

In other States and Countries they have other names, for example:

I. (Primal Slates and Sandstones) is always called Potsdam sandstone in New York and elsewhere, except in Tennessee, where it is called Ocoee and Chilhowee.

II. (Matinal Limestone) is called in the west the Great Magnesian Limestone formation. In the north it is called Calciferous sand-rock, Chazy, Birdseye, Black River and Trenton limestone. In Tennessee it is known as the Knoxville limestone.

III. (Matinal Slates) is the Utica and Hudson River slate in the north; the Cincinnati group of the west.

IV. (Levant Sandstone) which makes the North Mountain, Massanutton Mountain, etc., is called in the Northern States Oneida conglomerate and Medina sandstone.

V. (Scalent Shales) is the Clinton formation of New York and Pennsylvania, with its fossil iron ore beds.

VI is the Lower Helderberg limestone.

VII is the Oriskany sandstone, with its iron ores.

VIII includes the Upper Helderberg (at the bottom) Marcellus black slate, Hamilton flags, Genessee black slates, Portage flags and Chemung shales (at the top.)

IX is the Old Red Sandstone of England; the Catskill formation of the north.

X, with its coal beds, is the Pocono of Pennsylvania.

XI, the Mountain Limestone; Lewisburg Limestone of Virginia; the Mauch Chunk Red Shale in Pennsylvania.

XII, the Millstone Grit of England, the Pottsville Conglomerate of Pennsylvania, underlying XIII, the true Coal Measures.

I. The Primal or Potsdam sandstone formation lies upon the slope of the South Mountain or Blue Ridge along the south-east edge of the Eastern Shenandoah Valley, and so on northwards and southwards into Pennsylvania and Tennessee.

As a formation it is very thin in Pennsylvania and enormously thick in Tennessee. In Virginia it is one or two thousand feet thick and consists of conglomerates, sandstones and slates. It may be conveniently divided into

1. Lower slates.
2. Sandstones.
3. Upper slates.

In all of these three sub-divisions there are found more or less important deposits of iron ore.

1. In the *lower* slates occurs the so-called specular iron ore of the Blue Ridge, which has been extensively developed in Augusta, Rockbridge, Botetourt and Bedford counties. The ore is a red hematite, often intimately mixed with small grains of quartz; but at some points showing in a bed of considerable thickness and of good quality.

2. The Potsdam sandstone itself has in many places been found to contain important beds of brown hematite iron ore, which have been opened up at different points; as in

Page county on the Overall property, and in Rockbridge county on the Vesuvius property, where the bed attains a great thickness. The ore is generally a close-grained, brittle, dark-brown hematite, nearly always cold-short.

3. But from an economical point of view the *upper* slates are by far the most important, being one of the richest repositories of brown hematite ore in Virginia. They intervene between the Potsdam sandstone and the base of the calciferous limestone, and are generally more or less disintegrated or decomposed into varigated clays. They are found all along the western slope of the Blue Ridge, and are *geologically co-extensive* with it. This important point should be borne in mind in order to arrive at a proper appreciation of the mineral resources of the Great Valley. While they may not always carry a continuous bed of iron ore, yet, wherever they occur, deposits of brown hematite of greater or less extent may be confidently looked for.

It is this horizon that has supplied practically the whole of the stock to the old charcoal furnaces of the Shenandoah Valley;—to the Shenandoah Iron Company's furnaces, from the noted Smith and Fox Mountain Ore Banks in Page and Rockingham counties; the old Mount Torry furnace in Augusta; Cotopaxi, Buena Vista, Vesuvius and Glenwood furnaces in Rockbridge; and the Arcadia and Cloverdale furnaces in Botetourt county. In Pennsylvania, this horizon is represented by important banks in Lehigh county, furnishing a large amount of stock for the furnaces in the Lehigh Valley; at Pine Grove and Boiling Springs in Cumberland county; and at Pond Bank and Mont Alto in Franklin county.

II. The Matinal or Magnesian limestone formation is six thousand feet thick in Middle Pennsylvania, but not more than two thousand perhaps in Virginia.

In the north it is distinguished by an upper purer (Trenton) mass, and a much thicker lower magnesian mass. These limestone strata form the south-eastern half of the floor of the Great Valley in the Northern States, and almost and often quite all of it in the Southern States.

Innumerable caverns penetrate them underground in various directions. The Natural Bridge is merely a piece of

the roof of a cavern which once extended up and down the ravine which the bridge spans. The ravine is an ancient cavern with its ancient roof gone.

In such caverns and pot-holes of all sizes and shapes, iron-bearing mud has settled, filling them up entirely, and afterwards the iron has concentrated into masses or pipes or gravel of iron ore, (brown hematite or limonite.) Most of the iron ore of Pennsylvania and western New England is of this nature.

In the Shenandoah Valley these *limestone ores* have been as yet comparatively little developed; but in South-west Virginia, in Wythe county, they furnish nearly all the stock for the blast furnaces of the district. Commencing at Mack's Creek near New River and pursuing a course parallel to the Poplar Camp and Iron Mountains for a distance of thirty or forty miles, they have been developed in large quantity and of remarkable purity. There is perhaps no other portion of the Great Limestone Valley either in Pennsylvania or Virginia so rich in this variety of ore. The ore occurs in clay in clefts and cavities in the limestone; and although the deposits may be somewhat irregular, yet their extent is often very great. Doubtless much of the ore has been derived from the decomposition of iron pyrites; nodules and masses of this mineral partly decomposed being quite frequently found in the deeper workings; and the low percentage of phosphorus usually found in these ores seems to strengthen this view of their origin.

Along the middle or west side of the valley there is another important ore horizon somewhat similar in *character* although probably not in *extent*, to that found along the western slope of the Blue Ridge already described; and which, in some places of the Great Valley, has yielded rich deposits of iron ore.

It would appear, therefore, that in addition to the numerous *irregular* deposits of ore found at different horizons in the body of the great limestone formation, there are two *regular* lines of iron ore deposits running parallel with the valley; one representing the bottom of the limestone (in the slates and clays overlying the Potsdam sandstone No. I;) the other the top or close to the contact of either the

Magnesian or Trenton limestones with the slates of formation No. III. Or in other words, one line of ore deposits runs along the foot of the Blue Ridge; the other the middle or west side of the valley where the limestone land adjoins the slate land; but when faults or rolls occur the lines of ore deposits repeat themselves as often as the proper rocks come to the surface.

Practically the whole of the brown hematite ore used in the furnaces of the Lehigh Valley comes from one or the other of these horizons.

In addition to the iron ores already mentioned there are other important minerals found in the great limestone formation. Extensive deposits of lead and zinc ore have been successfully worked at different localities. These sometimes follow the lines of the bedding, but usually cross them or fill up pockets and irregular cavities, as they do in the limestone strata of Iowa and Wisconsin. Such is the lead mine of Wythe county, Virginia, and the Saucon zinc mine of Pennsylvania.

III. The slate formation proper contains, as a rule, no valuable deposits of ore. It is spread over the land in front of the North Mountain and rises upon its flank nearly to its summit. This is the same geological formation which in Pennsylvania furnishes the famous roofing slate of Lehigh and Northampton counties.

At or near the upper limits of the slate formation, however, or between it and the sandstones of IV, important beds of iron ore have been developed at several points; as on the Massanutton, Purgatory, Mays', Catawba and Draper Mountains.

In Pennsylvania this is not recognized as an iron ore horizon.

IV. The North Mountain itself is formed by a massive sandrock, which sometimes exhibits traces of iron ore, but seldom of any value.

V. On the back slope of the North Mountain, as well as on Massanutton Mountain, the lowest layer of *bloodstone* or *dyestone* iron ore appears at the surface. This is the *Block fossil* of Pennsylvania. In Tennessee and Alabama it is very thick; a bed of it thirty-five feet thick outcrops in the

back valley west of Knoxville, and two other beds of less size overlie it. In Virginia it is also sometimes very thick. In Fort Valley in the Massanutton range, a bed of it nearly thirty feet thick is said to have been proven over a considerable area. The *fossil ore beds* of Pennsylvania, however, are nearly a thousand feet higher in the series, and are not well represented in the Southern States.

VI. The Lower Helderberg limestone forms a valuable flux for blast furnace use. It is reported to attain a considerable thickness on Massanutton Mountain; but generally it is not well represented south of the Potomac.

VII. At the top of the Oriskany sandstone formation, which is a peculiar deposit of glass sand full of curious shells, lie great deposits of brown hematite iron ore, which in Pennsylvania belong to the Marcellus slate formation next above. This is the horizon from which the Longdale and Low Moor furnaces on the Chesapeake and Ohio railroad draw their chief supply of ore.

VIII. The Devonian rocks form the "Poor Valleys" of Virginia and contain no minerals but that last described.

IX. The Catskill formation is thin, and disappears going south.

X. The Pocono (Vespertine) sandstone forms the North (or Brushy) Mountain in southern Virginia, by reason of the great upthrow faults which run along the edge of the Great Valley. In this formation, or just at its top, lie the coal beds of Wythe, Montgomery and Pulaski counties, which have been quite extensively developed at numerous points for local use. Most of the coal used at the Salt Works at Saltville, and the Zinc Works at Pulaski is mined from this horizon. Although these coals have at present and may even continue to have a certain value for local use, yet the opening up of the Great Flat Top coal region with its superior coals will prevent their being used to any great extent except for local purposes.

XI. Over these coal beds lie one thousand feet of subcarboniferous limestone and shale—unimportant as a valuable mineral formation.

Before describing the various ore developments examined,

a brief reference to the different varieties of iron ore may be useful.

The compounds of iron are widely distributed in nature as minerals, those occurring in greatest abundance being the oxides, carbonate, bi-sulphide, phosphate, titanate, chromate and silicate. But for the extraction of the metal the only minerals which are considered suitable are the several oxides and the carbonate, all of which occur in great abundance—being generally more or less intimately mixed with varying amounts of earthy substances.

Ores of Iron.

The following are the most important ores of iron:—

1st. Those in which anhydrous ferric oxide or sesquioxide of iron forms the principal constituent. These are the different varieties of red hematite—including the fossil ores, specular ore or iron glance, and micaceous iron ore. They are characterized by giving a cherry red or reddish-brown streak when rubbed on unglazed porcelain, and a red color when finely pulverized. When *chemically pure* they consist of:—

Metallic iron,	70
Oxygen,	30
	100

But as found in nature they are generally more or less intimately mixed with argillaceous matter, quartz, &c.

2d. Those in which hydrated ferric oxide (or sesquioxide of iron) is the principal constituent. This group includes the different varieties of brown hematite, limonite, pipe ore, bog ore, &c.

There are, however, several hydrates of ferric oxide containing different amounts of water of hydration. The principal ones are *Limonite*, *Goethite* and *Turgite;* and these, either singly or more generally mixed together, form the bulk of our so-called brown hematite iron ores. They are characterized by giving a yellowish brown streak on unglazed porcelain and a yellowish brown powder. They are usually more or less intimately mixed with clay, sand, flint, &c.; and sometimes the oxide of iron is replaced by

varying proportions of oxide of manganese, forming what are commonly known as *manganiferous iron ores*. This variety when the percentage of phosphorus is low enough, becomes very valuable in the production of spiegel and ferro-manganese, which are now so extensively used in the manufacture of steel.

The three principal hydrates of ferric oxide already referred to, when chemically pure, have respectively the following composition:

	Limonite.	*Gœthite.*	*Turgite.*
Metallic iron,	59.92	62.98	66.29
Oxygen,	25.68	26.97	28.41
Water,	14.40	10.10	5.30
	100.00	100.00	100.00

3d. Those in which magnetic oxide of iron forms the principal constituent. These constitute our different varieties of magnetites or magnetic iron ores.

In this group, also, are included a great variety of ores in which more or less of the iron oxide is replaced by titanium or chromium oxide. But where the percentage of these elements is excessive the ores are seldom used as a source of iron.

Magnetic iron ores give a black streak on unglazed porcelain and a black powder when finely pulverized, and they are strongly attracted by a magnet. The color of the streak and powder readily distinguishes them from such common minerals as hornblende, pyroxene, &c., with which they are not unfrequently associated, and which are sometimes mistaken for magnetic iron ore.

When *chemically pure*, magnetic oxide of iron consists of:

Metallic iron,	72.41
Oxygen,	27.59
	100.00

4th. Those in which ferrous oxide (protoxide of iron) in union with carbonic acid forms the basis. This comprises the different varieties of carbonate iron ore—siderite, spathic iron ore, blackband and clayband ores.

When *chemically pure*, carbonate of iron consists of:

Metallic iron,	48.27
Oxygen,	13.80
Carbonic acid,	37.93
	100.00

The carbonate ores occur in considerable quantity in the Coal Measures in beds varying from a few inches to several feet in thickness; and they not unfrequently carry considerable carbonaceous matter—as, for example, the famous Blackband ore of Scotland.

Sometimes the carbonate of iron is replaced by varying proportions of the carbonates of manganese, lime and magnesia.

This brief description will suffice to show the general character of the different varieties of iron ore; and for a more ready comparison, the following table gives the percentage of metallic iron which each can obtain—*when chemically pure:*

Variety of ore.		*Percentage metallic iron.*
Magnetite,		72.41
Red hematite,		70.00
Brown Hematites,	Turgite,	66.29
	Goethite,	62.93
	Limonite,	59.92
Carbonate,		48.27

Ores of Manganese.

The ores of manganese are widely distributed in nature, and they are extensively used in the arts and manufactures. The principal ore, and that occurring in greatest abundance, is the peroxide (binoxide) or black oxide of manganese, known as the mineral pyrolusite. But the value of an ore depends generally on the uses to which it is to be applied.

Since the introduction of the Bessemer and Open Hearth steel processes, large quantities of manganese are used in this manufacture in the form of spiegel and ferromanganese—the former containing from ten to twenty per cent. of the metal, and the latter from twenty-five to fifty per cent. and over. *Spiegel* is generally used in the ordinary every-day manufacture of rail steel, while *ferromanganese* is employed when softer varieties of steel are desired.

The ores of manganese used in the production of these metals are commonly known as *manganiferous iron ores*, and they may contain from fifteen to forty per cent. metallic manganese, with a proper proportion of iron. It should be added, however, that ores for this purpose must contain only a small amount of phosphorus, so as to allow the production of a metal carrying a low percentage of this element.

But there is another and a very important use to which the ores of manganese are applied; namely: for the manufacture of bleaching powder, &c., so extensively used for bleaching linen and cotton goods. For this the purer varieties of ore only are used; and their value depends not so much on the percentage of metal which they contain, but upon the quantity of oxygen they can furnish when exposed to the action of acids, or—what amounts to the same thing—the quantity of chlorine which they are capable of eliminating when treated with hydrochloric acid. In this manufacture the peroxide (binoxide) or black oxide of manganese is directly the most valuable; and other ores of manganese are only valuable for this purpose in proportion to the amount of peroxide or binoxide they may contain. When chemically pure, binoxide of manganese contains 63.218 per cent. metallic manganese. In the English market the standard ore yields seventy per cent. binoxide of manganese; which is equal to 44.252 parts of the metal.

We will now describe the different ore developments examined.

CHAPTER I.

Iron and Manganese Ores.

SECTION I.

Mines along the line of the Shenandoah Valley Railroad.

These mines are for the most part opened up in the great belt of ferriferous slates and shales lying along the western slope of the Blue Ridge and geologically co-extensive with it. This great iron-ore bearing formation has already been referred to and described in a former part of this report.

Many of the ore developments—abandoned years ago—are now so completely fallen shut that no reliable estimate can be given as to the actual depth of ore mined out. But although they have supplied for a great many years the whole of the stock to the old charcoal furnaces of the Valley, yet it may be said that the surface has simply been scratched and that no thorough or systematic mining of the ore deposits has yet been made. The previous lack of railroad transportation and the ravages caused by the late war have doubtless had much to do with the present condition of affairs. But the recent completion of the Shenandoah Valley Railroad through to Roanoke—by affording the facilities for obtaining a supply of the very best of coke for fuel, and by opening up this section to markets in every direction—will doubtless be the means of causing these ore deposits to again receive the attention from Iron Masters which their good quality and great abundance seem to justify.

It should be stated here that the analyses given in the body of this report represent the ores dried at 212° F. Manganese has been determined in every case when present to the amount of one per cent or more. The developments will be described as far as possible in regular order from north to south, or rather from north-east to south-west.

Clarke County.

On the *Champ Shephard* property, near the Shenandoah river and four and one half miles south south-east from Berryville, a rich-looking porous brown hematite has been developed by open cut at several points on a high knoll. The cuts have been originally quite shallow, and they are now so completely fallen shut as to prevent any reliable estimate as to the prospect for ore. The territory proven is quite small, and the developments have not been made in such a way as to test whether the ore extends for any great depth. Practically no ore has been taken out of these openings for the last twenty years. Some shafts have been quite recently put down on top of the knoll, without, however, striking any body of ore. Several piles are now lying around the openings; and a sample of the ore, consisting of one hundred

and twenty-eight pieces, was selected from these to represent its average character. The analysis shows it to contain:

Protoxide of iron,	None.
Sesquioxide of iron,	71.143
Sesquioxide of manganese,	.007
Sesquioxide of cobalt,	.010
Oxide of zinc,	.010
Alumina,	3.950
Lime,	.290
Magnesia,	.468
Sulphuric acid,	.280
Phosphoric acid,	.162
Water,	12.480
Silicious matter,	11.140
	99.890
Metallic iron,	49.800
Metallic manganese,	.005
Sulphur,	.112
Phosphorus,	.071
Phosphorus in 100 parts iron,	.142

On the property of *Mr. A. Mason Moore*, three and one half miles south-east from Berryville, and one and one half miles north-east from the Champ Shephard bank, ore has been developed at several points by test pits. One only has been sunk to a depth of twenty feet, with a show of ore all the way down from surface. Some pits, however, put down quite near this have failed to find ore; but these are mostly shallow, and no regular or systematic work has been done here to prove the ore territory. Surface ore is quite abundant; and in a field near Mr. Moore's house float ore makes quite a bold show. Samples, ninety-two pieces selected from ore taken out of the different trial pits, yield the following analysis:

Metallic iron,	49.875
Phosphorus,	.146
Silicious matter,	11.430
Phosphorus in 100 parts iron,	.292

Warren County.

Rudisill property.—On this property, which is situated three miles north from Bentonville and about four hundred and fifty yards south-east from the line of the Shenandoah

Valley Railroad, iron ore has been developed by several small shallow cuts, the deepest of which is not over six feet. The ore crops to the surface, and in several cuts the show is quite abundant. The excavations cover an area of about one hundred yards in length in a N. N. E. and S. S. W. direction; and there are considerable surface indications between the pits. Judging from the size of the cuts and the quantity of ore on the bank, the yield of ore must have been quite great. It is an open, cellular *limestone ore.* A small but never-failing stream of water in the immediate vicinity affords good facilities for washing purposes. Samples, one hundred and twenty-seven pieces selected from the different openings, show the following:

Metallic iron,	43.125
Phosphorus,	.726
Silicious matter,	21.020
Phosphorus in 100 parts iron,	1.683

Overall Property.

Iron ore—both red and brown hematite—has been opened at several points on this property. The *Salina bank*, one and three fourths miles east from Overall Station, S. V. R. R., shows a vein of silicious red hematite 5′ 11″ thick. This is the most northern exhibit examined of the so-called specular ore of the Blue Ridge; but at this point the ore is very lean. The wall-rock consists of hard, sandy shales. Pressure from the south-east has caused the vein to snap and to be moved over in a north-west direction for a distance of 7 feet. The ore has been uncovered for about 75 or 80 feet, and a considerable quantity has been taken out; but so far as I could learn none of it has been shipped for trial in the blast furnace. A sample, forty-five pieces, consisting of a section of the vein at two points, yields:

Metallic iron,	16.025
Phosphorus,	.098
Silicious matter,	68.630
Phosphorus in 100 parts iron,	.611

About two and one half miles south-east from Overall station a bed of *brown hematite* ore has been opened on the south-east side of the "Third Ridge," in Potsdam sand-

stone. This is known as the "*New Mine.*" The bed is probably 2′ 6″ thick, but at different points the sandstone comes in and pinches out the ore considerably. Occasional tongues of sandstone run in through the ore, making careful mining necessary to obtain it free from sandrock. The rocks stand nearly vertical. The development consists of an open cut three and one half feet wide, forty feet long and about twenty feet deep, extreme measurement. Samples, eighty-five pieces, were selected—free from sandstone—from the ore in place. They yield—

Metallic iron,	56.375
Phosphorus,	1.275
Silicious matter,	1.890
Phosphorus in 100 parts iron,	2.261

On the "Second Ridge" at the *Haerriett Mine* the same general conditions prevail, although the ore is more intimately mixed with sandstone. The developments here consist of a rather narrow cut, thirty feet long, eight feet wide and eight feet at deepest point. Measurements on the bed could not be made, as the ore at the outcrop was so impregnated with sandstone that its wall-rock could not well be distinguished.

On the west face of the "Fourth Ridge" the same character of ore has been opened up, showing a bed 2′ 6″ thick. Here the ore is comparatively free from sandstone, and it has the appearance of a rich, brownish-black hematite. The wall-rock is Potsdam sandstone; and at some points it is so strongly impregnated with iron oxide as to have the appearance of red hematite ore, for which it has been mistaken. Thin seams of "*pitchy limonite*" occur at different parts in the ore bed; and such is its appearance that it was thought to be coal by those who were operating the mine. This bank is known as the "*Traister find,*" and is doubtless a continuation of the "New mine" deposit.

Page County.

On the property of *Mr. G. N. Roy*, adjoining the Overall, brown hematite ore has been developed in a small ravine on the west face of the "Fifth Ridge." It has been

stripped for twenty feet or more, but most of the material is simply a ferruginous sandstone similar to the wall-rock at the "Traister find." At no point was the ore seen over two feet thick, and then, seemingly, only as a lenticular mass. The character of the ore is similar to that found on the Overall property.

The *Hopper* development, situated on the "First Ridge" near Dry Run trestle and two miles north-east from Rileyville, consists of a circular cut forty feet in diameter and twelve feet deep. Ore crops to the surface, but its general character is lean and silicious. Probably twenty or thirty tons have been mined from the cut; but a sufficient amount of work has not yet been done to fully test the deposit. A sample, consisting of thirty-six pieces, was selected to represent the *best* of the ore. It shows:

Metallic iron,	46.850
Phosphorus,	.941
Silicious matter,	18.350
Phosphorus in 100 parts iron,	2.009

Two miles E. S. E. from Rileyville a deposit of ore has been developed by Harmer & Randle. This is known as the "*Bonanza mine.*" The exposure consists of a rather narrow cut, some forty-five feet long, across the face of a hill on the west side of a narrow ravine. The deepest point shows seven feet of solid ore, with ore in the bottom not gone through. At the northern end of this cut some additional stripping has been done; but at this point the ore shows, at present, quite sandy and lean. Sufficient work has not yet been done to justify any positive conclusions as to the size of the deposit; but the indications are quite favorable for a good body of ore. About two hundred tons have already been mined. A sample, consisting of one hundred and fifteen pieces selected from ore in place along the entire length of the cut, yields the following analysis:

Metallic iron,	47.475
Phosphorus,	1.096
Silicious matter,	14.580
Phosphorus in 100 parts iron,	2.309

On *Emanuel Alger's* property, half a mile from Honey Run trestle, S. V. R. R., a deposit of brown hematite ore has been uncovered for a length of twenty-five feet and a width of three or four feet, with an average of four feet over-burden. Additional work will be necessary to determine the value of the deposit. In appearance the ore is very similar to that at the "Bonanza mine," and is of a deep brownish-black color. The opening is in a narrow ravine, within a few yards of Honey Run creek. A sample, one hundred and fifteen pieces, was selected from ore in place along the entire length of the cut. It yields:

Metallic iron,	46.450
Phosphorus,	2.118
Silicious matter,	16.590
Phosphorus in 100 parts iron,	4.559

Two miles N. N. W. from Kimball station and one hundred and twenty yards from the line of the Shenandoah Valley Railroad, iron ore has been opened up by trial shaft on *Mr. Breckenridge Rust's* property. The development consists of a circular pit five feet in diameter and twelve feet deep, showing ore quite conspicuously in the sides of the shaft and within a few feet of the surface. Other small, shallow, insignificant pits have failed to show anything. Immediately adjoining this, large boulders of rich-looking ore crop to the surface. Considerable wash ore can be seen in the clay taken out of the largest trial shaft. The nearest stream for washing purposes is Jeremy's Run, three quarters of a mile distant; but a well sunk at this point would doubtless find sufficient water for washing the ore, as the large shaft is now filled for several feet with water. A sample, one hundred and fifty-three pieces, was selected from ore taken out of trial shaft, and from the outcropping boulders. It yielded:—

Metallic iron,	50.950
Metallic manganese,	1.455
Phosphorus,	.442
Silicious matter,	9.780
Phosphorus in 100 parts iron,	.867

This outcrop has been developed into a producing mine, and is now shipping ore of good quality. Its present work-

ings are being extended, although not rapidly, to give every evidence of affording shipments for many years. The position of the ore is such as to allow it easily to reach the valley of the Susquehanna and other Pennsylvania iron ore markets.

Beverly Ore Company's Mines.

The Donovan property, next to be described, is now owned and operated by the Beverly Ore Company, who are now shipping the ore from Ingham station on the line of the S. V. R. R. From February, 1883, to June, 1884, there have been shipped 3346 tons to furnaces in Pennsylvania. This output will, in all probability, be largely increased during the present year.

On the *Donovan property*, near the head of Watery Branch and one mile south-east from East Liberty Station, iron ore has been developed on a foot hill of the Blue Ridge, on the east side of a ravine. The bank exhibits a series of openings from which several hundred tons of ore have been mined. The principal development consists of a main open cut, fifty feet long, fifty feet wide and twenty feet deep, showing a good body of an open, cellular brown hematite ore. At the edge of the cut the ore shows within a few feet of the surface. Immediately under this and at a lower level in the ravine, a tunnel has been driven in, striking the ore solid at sixty feet and penetrating the mass for several feet. The tunnel has now fallen shut so that nothing can be seen. It is estimated that the floor of the main open cut is about thirty-five feet above the roof of the tunnel. The ore mined out of this tunnel presents quite a different appearance from that in the cut, being a *compact*, dark, rich-looking brown hematite.

About ten or fifteen yards further south, a second open cut has been made, showing six to eight feet of ore of the same general character as that in the main open cut. Still further south, some shallow cross-cuts show the presence of ore.

North from the main open cut some fifty yards, another cut has been made; but the sides are now so obscured by

wash that nothing can be seen. The ore lying around this cut seems to vary considerably in character: sometimes a rich-looking brown hematite, but generally shaly and more or less manganiferous. Other openings near this point show the same general features; and these numerous developments seem to indicate the presence of a considerable body of ore.

The railroad can be reached by easy down-grade; and should any of the ore require washing, an abundance of water can be obtained from a good spring on the property near the railroad, or from the Shenandoah river close by.

Separate analyses were made of the *cellular* (open cut) and *compact* (tunnel) ore. Open cut sample consists of one hundred and forty pieces, selected from ore-pile at chute. Tunnel sample, seventy-eight pieces, from ore mined from tunnel. The results of the analyses are as follows:

	Cellular ore.	*Compact ore.*
Sesquioxide of iron,	74.678	77.285
Sesquioxide of manganese,	4.619	1.582
Sesquioxide of cobalt,	.080	.150
Oxide of zinc,	.040	None.
Alumina,	1.415	1.573
Lime,	.670	.950
Magnesia,	.320	.414
Sulphuric acid,	.052	.017
Phosphoric acid,	.233	1.152
Water,	11.810	12.480
Silicious matter,	6.310	4.380
	100.227	99.983
Metallic iron,	52.275	54.100
Metallic manganese,	3.216	1.102
Sulphur,	.021	.007
Phosphorus,	.102	.503
Phosphorus in 100 parts iron,	.195	.929

Shenandoah Iron, Lumber, Mining and Manufacturing Company.

This Company owns in fee simple about thirty-three thousand acres of mineral, timber and farming lands, situated in the south-western portion of Page and the north-eastern portion of Rockingham counties, about midway in length of the famous Shenandoah valley. Of this about twenty-

two thousand five hundred acres are embraced in what is known as the Massanutton tract, on a range of mountains running along the middle of the valley for nearly fifty miles, dividing the Shenandoah valley into two distinct valleys, those of the North and South Forks. On this tract is located the old Catherine furnace, now out of blast. Iron ore is reported to occur here in large quantity; but no examination of it was made, the district being considered outside of the scope of the present report. But on the other lands belonging to this Company, lying along the western slope of the Blue Ridge, several important developments were visited and samples selected for analysis. These may be described as follows:—

Smith bank, situated three and one fourth miles E. N. E. from Milnes' station, S. V. R. R., exhibits a series of irregular-shaped open cuts, from which a large amount of ore has been taken for use in the old furnace. The bank is not at present worked, although preparations are being made to re-open it. Most of the openings are now so completely fallen shut as to prevent any useful description of them. Foltz Run, in the immediate vicinity, affords a constant supply of water for washing purposes. Ore territory has been proven by trial shafts for a distance of nearly four miles in a north-east and south-west direction. A sample of the ore, one hundred and nine pieces, from the old dumps and from several trial shafts, shows the following:

Metallic iron,	49.900
Phosphorus,	.101
Silicious matter,	14.670
Phosphorus in 100 parts iron,	.202

The *Boyer or Stony Run* ore bank is situated about three miles north of Fox Mountain bank, and two miles east from the "Gem" furnace. It has just been opened up, and at present shows a face of ten or twelve feet of lump ore with six feet over-burden. A sample of the ore, eleven pieces, yields:

Metallic iron,	50.925
Phosphorus,	.297
Silicious matter,	13.950
Phosphorus in 100 parts iron,	.583

This has since been developed into a producing mine, and is now yielding about 50 tons per day of excellent ore, with a good show for the future.

The *Kimball bank*, lying three miles east from Milnes' station, consists of two excavations or cuts, namely: the *Atwood* and *Bolan*. The *Atwood* is a large, irregular-shaped open cut, from which some two thousand tons of ore have been mined. The ore at this point carries considerable manganese; and as the analysis given underneath shows it to be comparatively low in phosphorus, it may prove valuable in connection with other ores for the manufacture of spiegel. A narrow gauge road about four hundred yards in length connects the bank with the branch road of the Shenandoah Valley Railroad.

From the *Bolan* cut about four thousand tons of ore have been mined. The ore comes close to the surface and is somewhat shaly in character, although the bank yields a large proportion of rich bomb-shell ore. It does not carry so much manganese as that from the Atwood cut. Wolf Run affords good washing facilities. The washer is a double shaft, twenty-five feet long, operated by steam power.

Neither of these banks were in active operation when visited, although preparations were being made to work them extensively. A sample of the ore, one hundred pieces, (two thirds from the Atwood and one third from the Bolan,) selected from loose ore lying around and from small pile at shipping wharf, shows the following analysis:

Metallic iron,	**40.875**
Metallic manganese,	**7.349**
Phosphorus,	**.084**
Silicious matter,	**15.440**

The *Merica bank* is opened near Young's Run, three miles south-east from the Shenandoah Iron Works. The bank has been worked by an irregular-shaped open cut, from which about one thousand five hundred tons of ore have been mined. The ore consists of both lump and wash ore. Young's Run affords a good water supply for washing. The bank is distant one and one half miles from the

branch of the S. V. R. R. A sample, one hundred and seventy pieces, was selected from a pile of ore at the mine to represent the lump and wash ore. It yielded the following:

Metallic iron,	44.450
Phosphorus,	1.092
Silicious matter,	16.690
Phosphorus in 100 parts iron,	2.456

Garrison Tract.

On this Company's property, on what is known locally as the Garrison tract, about two miles east of the main line of the S. V. R. R., there has been recently opened up quite a promising deposit of manganese ore. Mr. Milnes, President of the Shenandoah Iron Company, in a recent communication, says that they have uncovered it thirty feet long with an average width of fifteen feet, while a shaft has been sunk on it to a depth of fifteen feet. The top consists of fine ore, which becomes much coarser and harder as it goes down; and the development thus far made would seem to indicate a considerable body of it.

The character of the ore is shown by the following analyses:

	Fine ore.	*Lump ore.*
Metallic manganese,	52.691	53.656
Metallic iron,	2.325	1.537
Phosphorus,	.324	.327
Silica,	2.795	1.955

Rockingham County.

Fox Mountain Bank.

This is by far the most important development. It is worked by open cut on the top of Fox Mountain, a low, flat-crested ridge situated about five miles S. S. E. of the Shenandoah Iron Works, and one thousand two hundred yards from the old charcoal furnace. The cut is of an oblong shape, four hundred and fifty feet long, three hundred feet wide and eighty-five feet deep at deepest point. The present working face of ore is not less than three hundred feet. The ore occurs in variegated clays—sometimes in

solid masses of considerable thickness. Tunnels have been driven in for a distance of a hundred yards from present ore face, showing ore all the way along; and a shaft has been sunk to a depth of fifteen feet in the floor of the cut, with ore in the bottom not gone through. This makes the proven depth or thickness of the ore material to be at least one hundred feet. Ore territory has been proven in a south-west direction for nearly five hundred yards. An open cut here is about thirty feet deep, ore having been struck at six feet from surface. Probably a thousand tons have been mined from this cut.

At many points in the present workings the ore comes practically to the surface, although the over-burden will probably average five feet. The bank yields about one third clean lump ore, which is shipped direct to the furnace over the branch railroad. The wash ore material is hauled over a tramway through a cut on the eastern edge of the deposit, to the washer located near its mouth. The washer is a double shaft, twenty-five feet long, run by steam power. Water for washing purposes is at present obtained from Dry Run; but as this supply is not permanent, arrangements are being made to bring it from Naked Creek, which will yield an abundance at all seasons. The ore material washes one half; and the capacity of the washer is at present eighty tons of clean ore per day. A sample of the *lump ore*, one hundred and forty-five pieces, was selected from a section across the whole face of the deposit. It yields the following analysis:

Protoxide of iron,	None.
Sesquioxide of iron,	75.321
Sesquioxide of manganese,	1.831
Sesquioxide of cobalt,	.130
Oxide of zinc,	.050
Alumina,	2.100
Lime,	.550
Magnesia,	.331
Sulphuric acid,	.025
Phosphoric acid,	.609
Water,	12.398
Silicious matter,	6.910
	100.255

Metallic iron,	52.725
Metallic manganese,	1.275
Sulphur,	.010
Phosphorus,	.266
Phosphorus in 100 parts iron,	.504

A separate sample of the *wash* ore shows:

Metallic iron,	49.000
Metallic manganese,	.850
Sulphur,	.033
Phosphorus,	.221
Silicious matter,	11.360
Phosphorus in 100 parts iron,	.443

While the above analyses fairly represent the average of the whole bank, there are varieties of the ore which give results varying widely in phosphorus. Some of it has been analyzed showing only six-hundredths of one per cent., and again the phosphorus has been found as high as half of one per cent., as in the following analysis of samples selected from the west face of open cut, sixty feet from surface:

Metallic iron,	52.050
Metallic manganese,	.677
Phosphorus,	.566
Silicious matter,	6.930
Phosphorus in 100 parts iron,	1.087

From this Fox Mountain bank the Company are now producing 100 tons of good ore daily, which they use in their coke furnace.

Shenandoah Iron Works.

The Shenandoah Iron Works have been in successful operation for a number of years, producing an excellent quality of metal. These works consist of a charcoal blast furnace, forge and refinery, and a large coke furnace recently built. The charcoal furnace is located on Naked Creek, near the end of the branch road and some five miles from Milnes' station. The stack is 33×8½ feet, with Player hot-blast attachment. The engine is an old pattern, 25 horse-power, with 2½-foot stroke. The capacity of the furnace is sixty tons per week of warm-blast charcoal iron, which is worked up into blooms at the Company's forge. An analysis of a sample of the pig-iron shows it to contain the following:

Charcoal Iron.

Carbon, combined,	.683
Carbon, graphitic,	3.330
Silicon,	1.494
Sulphur,	.003
Phosphorus,	.383
Manganese,	1.607
Iron, (by difference,)	92.500
	100.000

At one time the furnace was run on a mixture of two-thirds coke and one third charcoal, and an analysis of the pig-iron made at that time shows:

Silicon,	.689
Sulphur,	.058
Phosphorus,	.186

The dimensions of the new coke furnace are as follows: Stack 70×16 feet; bell, 7 feet six inches; tuyeres, 6 in number, with 5-inch nozzle, placed 6 feet from bottom of hearth; 9 boilers; upright blowing engine built by the Sheppard Iron Works, Buffalo, New York; steam cylinder, 42 inches with 7-foot stroke; blowing cylinder, 100 inches with 7-foot stroke; diameter of wheel, 24 feet; separate steam pumping and hoisting engines, the latter a Stokes & Parish; hot ovens, Grove's pattern, with 66 pipes; engine-house, 42×27×60 feet; cast-house, 62×100×36 feet, with stone foundations, brick walls and shingle roof, stock-house, 50×100 feet, frame. The machine work was built by Cruikshank, Moyer & Co., Danville, and the brick and other work by the Company. The estimated capacity of the furnace is seventy to eighty tons per day. Coke will be used as a fuel. For the present the supply will be obtained from Connellsville; but as soon as the New River Division of the Norfolk and Western Railroad is completed to Pocahontas, it is contemplated using the coke made from the Flat Top coal.

The new coke furnace of this Company is called the Gem furnace, and has now been in operation a little over a year, producing, from February, 1883, to February, 1884, 16,585 tons of foundry and forge iron. Owing to the unsatisfac-

tory workings of the old hot blast stoves, fully two months were lost in necessary repairs, so that the above product practically represents the output for ten months.

Recently three new Whitwell hot blast stoves have been added to the plant; and while with the old stoves the best daily yield was 60 tons, the furnace has already produced 87 tons per day, and it is fully expected the yield will ultimately reach 100 tons per day. The pig iron has been shipped to Harrisburg, Philadelphia and Baltimore markets and has given universal satisfaction. Its quality may be judged from the following recent complete analyses of two samples of foundry and one of forge iron:

	Foundry iron.		*Grey Forge iron.*
Carbon, graphitic,	3.255	3.446	3.156
Carbon, combined,	.378	.314	.605
Silicon,	2.092	1.941	.973
Sulphur,	.031	.025	.061
Phosphorus,	.636	.659	.601
Manganese,	1.153	1.174	1.174
Cobalt,	.165	.176	.178
Copper,	trace.	trace.	trace.
Calcium,	.102	.057	.124
Magnesium,	.021	.017	.019
Iron,	92.185	92.255	93.085
	100.018	100.064	99.976

The Company's forge is located near Milnes' station, on the line of the Shenandoah Valley Railroad. The plant consists of one run-out fire, with a capacity of eight tons per day of twelve hours; seven forge fires, with same capacity; and a Ferris & Miles double-acting steam hammer. The product consists of charcoal blooms for boiler plates. The iron from this district has long had an enviable reputation for its great purity; and the following analysis of a bloom fully substantiates this claim:

Carbon,	.042
Silicon,	.008
Sulphur,	.001
Phosphorus,	.074
Manganese,	.003
Iron, (by difference,)	99.872
	100.000

Wilmer and Jackson's Property.

The *Wilmer and Jackson* property adjoins the Fox Mountain tract on the south side. Iron ore is now being developed by open cut at a point one mile south-west from the Shenandoah Iron Company's No. 2 charcoal furnace. The exposure consists of a drift one hundred feet long and ten feet wide, ore material showing practically the whole length. At the north-east end of the drift the present working face of ore is eighteen feet wide and fifteen feet deep, with three feet over-burden. The ore occurs in variegated clays and consists for the most part of wash-ore, with occasional masses of lump ore. Several other small cuts have been made from which some ore has been mined; and ore territory has been proven in a north-east and south-west direction for some distance. It is supposed to be a continuation southwards of the Fox Mountain deposit; but the developments have not been carried sufficiently far to show whether the ore exists in a large body. The nearest stream for washing purposes is Dry Run Creek, one quarter of a mile distant, affording a water supply only during six months of the year. Samples, one hundred and forty-five pieces, of the *clean lump ore* yield:

Metallic iron,	50.450
Phosphorus,	.217
Silicious matter,	14.360
Phosphorus in 100 parts iron,	.430

On the land of *Mr. George W. Berlin*, two miles S. S. E. from One-Hundred-and-Twenty-Mile Station, ore has been exposed near the bed of Big Run Creek in an open cut thirty feet long and twelve feet wide. The ore has simply been uncovered, and no work has been done to test the deposit, which shows about six feet thick; at points being a highly crystalline black oxide of manganese. At some depth from the outcrop the quality of the ore may prove richer. Samples, one hundred and five pieces, were taken from ore in place along the entire length of the cut. They yield on analysis:

Metallic iron,	31.500
Metallic manganese,	16.778
Phosphorus,	.185
Silicious matter,	14.840

Abbott Iron Company's property.

Iron ore has been developed and mined at several places on this property to supply stock to the old Mt. Vernon furnace. The furnace is situated near Madison creek, but is now out of blast and in bad condition. The stack is 35×8½ feet, with two tuyeres and hot-blast attachment; furnace run by steam and water power; capacity, seven and one half tons of charcoal iron per day. Four ore banks have been operated to supply the furnace.

The *Weaver upper and lower banks* lie about two and a half miles south-east from Lynnwood switch S. V. R. R., and four miles east south-east from Port Republic. The lower bank consists of an open cut one hundred and twenty five feet long, seventy-five feet wide and twenty-five feet deep. The upper bank, which is a continuation south-west of the other, consists of a cut three hundred feet long, forty feet wide and twenty-five feet deep. The openings have not been worked for some time, and the sides have slipped down so that but little can be seen. Occasional thin streaks of ore are yet exposed; but no reliable estimate can be given as to the prospect for a large body of it. The stripping at this point is rather heavy—sometimes as much as ten or twelve feet. Wash ore preponderates at both openings. Lewis lower run furnishes a convenient supply of water for washing. A sample of the ore, one hundred and thirty-eight pieces, from both openings shows the following analysis:

Metallic iron,	43.700
Phosphorus,	.124
Silicious matter,	18.730
Phosphorus in 100 parts iron,	.283

On the same property, one and one-half miles from Lynnwood switch and three miles east from Port Republic, the

Raines bank has been worked near Lewis upper run. The development consists of a long irregular open cut with side drifts, the latter now fallen shut and the former considerably covered up by wash material and by clay-slides. At several points quite rich-looking masses or seams of cellular ore may yet be seen one or two feet thick, and at the south-west end the show is quite promising. The cut is about one thousand feet long, fifty feet wide and twenty-five feet deep, extreme measurement, running in a north-east and south-west direction—the ore showing principally in the west face of the cut. The deepest workings are now filled to a depth of several feet with water; but no trouble from this source is said to have been experienced in working the bank. Probably two-thirds to three-fourths of the deposit is wash ore. Lewis upper run affords a permanent supply of water for washing the ore. A sample, consisting of one hundred and sixty-three pieces, was selected from loose pieces of the ore all along the cut. It yields:

Metallic iron,	45.250
Phosphorus,	.281
Silicious matter,	19.210
Phosphorus in 100 parts iron,	.620

The *Miller bank* is situated one mile from the old Mt. Vernon furnace, four miles south south-east from Port Republic and two miles from Weyer's Cave station. It has been worked by an irregular-shaped open cut one hundred and fifty feet wide, two hundred and fifty feet long and thirty feet deep, extremes. The ore faces are now completely covered up by wash, and nothing can be seen in the bank. The ore has also been worked by a shaft and tunnel, but these are now practically fallen shut. In an east north-east direction a considerable area has been proven by shafts to be ore territory. Quite a good deal of wash ore may be seen in the several ore dumps. A small stream two hundred and fifty yards from the bank furnishes a constant supply of water for washing purposes, except during very dry weather; but Madison Creek, one mile distant, at the

furnace, can be reached by easy down grade with an abundant supply of water at all seasons.

From this bank to the Weaver opening already described the distance is about five miles; and this property is said to extend along the great ferriferous shale horizon in a general north-east and south-west direction for a length of eight or nine miles.

A sample of wash ore, one hundred and seventy-eight pieces, from the old dumps at the Miller bank yields:—

Metallic iron,	46.200
Phosphorus,	.242
Silicious matter,	16.220
Phosphorus in 100 parts iron,	.523

Augusta County.

Crimora Manganese Mine.

On the property of the *Virginia Manganese Company* near the mouth of Turk's Gap of the Blue Ridge, seven miles north-east from Waynesboro' and two miles east from Crimora station, S. V. R. R., there has been opened and successfully worked for many years a large deposit of manganese ore. This is generally known as the *Crimora Manganese mine.* The daily output at present is from twelve to fifteen tons, a large proportion of which is shipped to England. The mine is developed by shaft and side drifts. The present shaft is one hundred and five feet deep. At a depth of seventy-five feet, side drifts were run in and from these some four or five thousand tons of ore were mined.

At the bottom of the shaft where the present operations are being conducted, a drift has been run in an east and west direction for a distance of ninety feet, the ore being struck at fifteen feet from the edge of the shaft; and at a point sixty feet from the edge of the shaft, another drift has been run in a north and south direction for a considerable distance, showing ore all the way along. The drifts are 7×7 feet. Occasional horse-backs of clay have been encountered; but wherever examined the ore was found to be tolerably solid. There can be no doubt but that the deposit

is an extensive and valuable one. A twenty-five horse power engine runs a washer, crusher and saw-mill. All of the ore is washed, the output of the mine yielding three fourths clean ore. The washing is done in a cylinder which screens out the fine ore, the proportion of this being about one twelfth of the whole. The capacity of the washer is from 1,000 to 1,500 pounds, and seven minutes suffice to wash this clean. The fine ore is shipped principally to Pittsburgh; and the lump ore is put into bags—averaging about 400 pounds—for shipment to England.

A sample of the *lump ore*, two hundred and twenty-eight pieces, from pile on wharf shows the following analysis:

Binoxide of manganese,	81.703
Protoxide of manganese,	7.281
Sesquioxide of iron,	.533
Oxide of cobalt,	.354
Oxide of nickel,	.096
Oxide of zinc,	.623
Oxide of copper,	None.
Alumina,	.896
Baryta,	.829
Lime,	.880
Magnesia,	.630
Sulphuric acid,	None.
Phosphoric acid,	.171
Alkalies,	.467
Water,	3.405
Silica,	2.132
	100.000

Metallic manganese,	57.291
Metallic iron,	.373
Phosphorus,	.075

As the English standard is 70 per cent. of binoxide of manganese, the value of this ore may be better appreciated.

Since this mine was visited a branch road has been run in connecting it with the main line of the Shenandoah Valley railroad, thus greatly facilitating the shipment of the ore. The following table giving the number of tons shipped per month shows the steady increase in the producing capacity of the mine and in quantity of ore shipped. While from June 1, 1882, to June 1, 1883, there were shipped only 3,356

tons, there have been shipped from June 1, 1883, to June 1, 1884, 7,163 tons.

Table showing shipment of manganese ore in tons per month:

Months		Tons of 2,000 Pounds.
June,	1882,	
July,	"	18.4
August,	"	243.6
September,	"	302.7
October,	"	346.5
November,	"	370.1
December,	"	205.3
January,	1883,	
February,	"	97.2
March,	"	1,165.3
April,	"	259.6
May,	"	347.6
June,	"	367.2
July,	"	481.9
August,	"	390.8
September,	"	228.0
October,	"	633.5
November,	"	608.7
December,	"	604.7
January,	1884,	161.5
February,	"	150.5
March,	"	978.0
April,	"	990.1
May,	"	1,568.6

Mount Torry Furnace Property.

The old Mount Torry furnace—now out of blast—is located about four and one half miles from Sherando station, S. V. R. R., and the ore bank about three and one half miles from the railroad and about two miles from the furnace. The bank exhibits a series of openings which have not been worked for some time and are now much fallen shut. The principal one is known as *Gaw's cut*, and consists of an irregular-shaped open cut about one hundred feet long, fifteen to thirty feet wide and about twenty feet deep. The ore from this cut was chiefly lump; and occasional boulders of a friable cellular ore may yet be seen in the faces of the cut, although the mass of the deposit is obscured by wash material. About six feet of stripping

covers the ore on top. A considerable quantity of wash ore material has been taken from this cut and is now lying at its mouth. The nearest water for washing purposes is Mill's Creek, about three quarters of a mile distant, which furnishes a rather irregular supply. Ore has been washed on one part of the property, the water being obtained from a spring; but in dry weather the supply fails.

A few yards west of the main cut a shaft has been sunk to a depth of forty to forty-five feet. Ore was reached at a depth of about twenty feet; and a side drift in a S. S. E. direction is said to have yielded a considerable quantity of lump and wash ore. Several other openings of considerable size have been made in the vicinity from which a good deal of ore is said to have been mined; but the faces were so obscured by wash that nothing could be seen. A sample of the ore from *Gaw's cut*, one hundred and sixty-five pieces taken from ore pile at the furnace, yielded:

Metallic iron,	48.450
Phosphorus,	.539
Silicious matter,	14.660
Phosphorus in 100 parts iron,	1.112

About three-eighths of a mile north-east from the furnace and three hundred yards from Back Creek, several beds of silicious *red hematite* have been developed along a narrow ravine in a foot hill of the Blue Ridge. One bed having a thickness of 3′ 4″ has been uncovered for forty feet; and a second bed 8′ 6″ thick has been uncovered for twenty feet. The ore in both openings is of the same general character. It mines easily in square blocks; and about one hundred tons have been taken out for use in the furnace, where it is said to have worked satisfactorily. A sample from *the lower bed*, consisting of seventy pieces taken from the ore pile, yields:

Metallic iron,	22.650
Phosphorus,	.148
Silicious matter,	63.700
Phosphorus in 100 parts iron,	.653

Kennedy Iron Tract.

This adjoins the Mount Torry furnace property on the south. It lies in the mineral belt extending along the western slope of the Blue Ridge, in which are located nearly all the banks already described. Surface indications are quite favorable at many points on the property; but no systematic development of its ore deposits has yet been made to test their extent. Numerous small and shallow test pits have been sunk and some ore obtained for use in the small blast furnace operated at this point many years ago. Two open cuts twelve to fifteen feet wide, situated about three miles from the Shenandoah Valley Railroad, (Stuart's Draft station,) are now practically fallen shut; but they are said to have yielded considerable ore. A sample, forty-seven pieces selected from ore lying around dumps, shows:

Metallic iron,	52.575
Phosphorus,	.289
Silicious matter,	7.930
Phosphorus in 100 parts iron,	.549

About three hundred and fifty to four hundred yards from the above, another small test pit has been sunk showing a good quality of *manganiferous iron ore.* But this excavation has also fallen shut and nothing can now be seen. A sample of the ore, sixty-five pieces, selected from loose ore lying around, yields:—

Metallic iron,	17.450
Metallic manganese,	30.788
Phosphorus,	.089
Silicious matter,	11.950

Cotopaxi Furnace Property.

Ore for the old Cotopaxi furnace was obtained from several banks opened up on this property.

The *Bear bank* is situated about two and one half miles south-east from the Shenandoah Valley Railroad at Greenville station. It has been worked by an irregular-shaped open cut in the face of a hill, out of which a good deal of ore must have been mined; but operations were abandoned twenty-five years ago, and the sides of the bank have so

completely fallen shut that no reliable estimate can be given of the depth of ore mined out. Occasional boulders of a rich-looking brown hematite may yet be seen in the faces of the cut; but these are not sufficient to afford reliable indications of the prospects for a future supply of ore. Near the top of the bank large masses of an argillaceous, red-looking ore crop out; and all around the edges of the bank the show of wash outcrop ore is quite abundant. The ore taken out of the bank is said to have been principally lump ore. No washing has been done here, as there was no regular or sufficient supply of water for this purpose in the immediate neighborhood. A sample of the ore, seventy two pieces, was selected from the old dump, which yielded on analysis:

Metallic iron,	49.400
Phosphorus,	.062
Silicious matter,	14.260
Phosphorus in 100 parts iron,	.125

The *Black Rock bank* is opened up about a quarter of a mile south-east from the Shenandoah Valley Railroad, and one and one-fourth miles S. S. W. from the old Cotopaxi furnace. The exposure consists of an irregular-shaped open cut four hundred and fifty feet long, one hundred feet wide and sixty feet deep, extreme measurements. An occasional boulder of ore crops out in the sides of the bank, but generally the ore faces are obscured by wash material. At the north-east end of the cut a tunnel is said to have been driven for a distance of eighty feet in ore; but this is now fallen shut. Several small and shallow pits sunk on the north side of the bank showed ore in each case coming close to the surface. Near the old tunnel, the bank shows considerable loose ore lying around—generally cellular in character, with cells more or less filled with a white clay. No water for washing the ore is available in the immediate vicinity; but the South River of James can easily be reached at the old furnace one and one-fourth miles distant. A sample of the ore, one hundred and eighty-five pieces from loose pieces lying near the tunnel, shows:

Metallic iron,	38.950
Phosphorus,	.095
Silicious matter,	28.290
Phosphorus in 100 parts iron,	.244

Newton's Property.

Mine bank, on Newton's property, lies three miles east from the old Cotopaxi furnace and four miles from the line of the Shenandoah Valley Railroad. It is opened on a steep ridge near the head waters of the South River of James and about five hundred yards from the stream. An abundant outcrop of ore covers the ridge for a considerable area. Sometimes the ore is a quite pure oxide of manganese, while again, it occurs comparatively free from this element—frequently in beautiful fibrous masses, the fibers being often six inches in length. On the east face of the ridge the ore has been opened up by a shallow, narrow cut; and the exposure here shows the iron ore highly charged with oxide of manganese. But little mining has been done, and no shafts have been sunk to test the extent of the deposit which, to judge by surface indications, must be considerable. A sample of the ore, one hundred and forty-three pieces from along the face of the open cut, shows it to contain:

Metallic iron,	41.125
Metallic manganese,	8.221
Phosphorus,	.265
Silicious matter,	14.880

Rockbridge county.

Vesuvius property.

Iron ore has at one time been quite extensively opened up on this property to supply the stock for the old Vesuvius furnace; but many of the developments have now fallen shut and very little can be seen.

The Kelly bank has been opened up 1½ miles from the S. V. R. R., (Vesuvius station.) It was worked by open cut and tunnel; but these have so completely fallen shut that no useful description can be given. A considerable

deposit of rich manganese ore is said to have been developed by the workings; but so little of the ore could be seen that it was not thought advisable to select any for analysis owing to the difficulty in procuring a fair average of the deposit.

The Cold Short, Donald or Dogwood Hollow bank lies two and one half miles from the Shenandoah Valley railroad. It is opened on a spur of the Blue Ridge, fully a thousand feet above the railroad level. The development consists of a rather narrow, shallow open cut probably fifty yards long, near the top of the ridge. The ore occurs between nearly vertical layers of Potsdam sandstone, and forms a bold outcrop up the face and on top of the ridge. The ore bed shows a width of ten feet of solid ore, with walls of leaner ore. Occasional tongues or irregular masses of sandstone come in and cut it out at points; but generally this feature is not very pronounced. Although some of the ore has been mined for use in the old Vesuvius furnace, yet it may be said that the deposit is practically undeveloped. But the surface indications alone point to the presence of a large body of ore. A sample, one hundred and twenty-eight pieces, was selected from ore in place along the entire length of the open cut. It yielded on analysis the following results:

Sesquioxide of iron,	74.893
Sesquioxide of manganese,	.433
Sesquioxide of cobalt,	.030
Oxide of zinc,	None.
Alumina,	1.005
Lime,	.740
Magnesia,	.360
Sulphuric acid,	.012
Phosphoric acid,	8.357
Water,	11.318
Silicious matter,	8.050
	100.198
Metallic iron,	52.425
Metallic manganese,	.302
Sulphur,	.005
Phosphorus,	1.466
Phosphorus in 100 parts iron,	2.796

The *McClung bank* is situated 1 mile south-east from the

line of the Shenandoah Valley railroad. It has been developed by an open cut three hundred feet long, twenty-five feet deep and fifty feet wide, extreme measurements. The bank has not been worked for thirty years; and although the ore faces are generally covered up with wash material, occasional masses of a fairly rich ore may yet be seen in the sides of the bank near the surface. A sample, consisting of one hundred and fifteen pieces, was selected from all the exposures. It yielded on analysis:

Metallic iron,	42.575
Phosphorus,	.321
Silicious matter,	21.610
Phosphorus in 100 parts iron,	.753

Buena Vista property.

Large deposits of brown hematite iron ore have been developed at numerous points on this property. Where the present operations are being conducted the ore has been worked by open cut, shaft and side-drifts. This is known as the "*Second or Engine-house opening*," and is situated about three-fourths of a mile east from the Shenandoah Valley Railroad. The open cut consists of a circular pit one hundred and twenty feet in diameter and nearly fifty feet deep, from which a large amount of ore has been mined The ore comes near the surface at points, with probably an average of six feet of stripping. At the edge of the deposit and outside of its limit, a shaft has been sunk to a depth of ninety-one feet; and it is by means of this that the present mining operations are being carried on. At a level of fifty feet a side drift was run in, and about 5,000 tons of ore mined from this point. But the present workings are on a lower level, viz: at a depth of seventy-six feet. Here a side drift in an easterly direction has been run in for a distance of seventy-two feet, where the ore bed was reached; thence in the same direction for sixty-five feet in good, rich, almost solid ore. At a point twenty-seven feet from where the ore was first struck, a drift runs in a S. S. W. direction for sixty-three feet through the same general character of ore. A slight flinty horse-back, seven to eight feet wide, was

encountered twenty-seven feet from the north end of this drift. But the occurrence seems purely local, for another drift in an easterly direction at this point goes through twenty feet of good rich ore, almost solid, with but few flint streaks.

The general "strike" of the ore deposit is north-east and south-west, with an easterly dip; and it has been traced in a south-west direction for a considerable distance. There can be no doubt but that the deposit is an extensive one. The bank yields one half clean lump ore; and the bulk of the so-called wash ore must be simply the lump ore broken up in mining, for at no point examined does the bed show much clay. The fine ore washes three fourths clean ore. The washer is located at the North River of James, three fourths of a mile distant, easily reached by down grade. The shaft is fifteen feet long, run by water power, and it has produced as much as fifty tons of clean ore in one day of twelve hours. But the daily out-put of the mine is at present only twenty tons, all of which is shipped to the Company's "Amherst furnace" on the James river, twenty miles distant. The mine is well timbered and in good condition, and can be made to yield a much larger out-put, especially if worked by open cut. The hoist is worked by a twenty horse-power engine; and a steam pump keeps the mine quite dry. A sample, consisting of one hundred and ninety-six pieces, was selected from the ore pile at mine to represent the lump ore. It yields the following analysis:

Sesquioxide of iron,	77.643
Sesquioxide of manganese,	.568
Sesquioxide of cobalt,	.020
Oxide of zinc,	Trace.
Alumina,	.747
Lime,	.430
Magnesia,	.324
Sulphuric acid,	.040
Phosphoric acid,	.446
Water,	10.310
Silicious matter,	9.390
	99.918

Metallic iron,	54.350
Metallic manganese,	.396
Sulphur,	.016
Phosphorus,	.195
Phosphorus in 100 parts iron,	.358

"*No. 1 opening*" (*Buena Vista*) consists of an open cut four hundred feet long, one hundred and fifty feet wide and fifty feet deep, extreme measurements; situated about four hundred yards S. S. W. from the "No. 2 or Engine-house opening" just described. The deposit is said to have been traced connecting the two banks. No ore has been mined from this point since 1865, and the sides of the bank are now much covered with wash material. At the bottom of the cut a shaft is said to have gone down forty feet in ore; and near the N. N. E. end another shaft is said to have shown one hundred and seventy feet of ore material; but these are now completely fallen shut. The ore is reported as being of the same general character as in the No. 2 opening, although not quite so solid.

One hundred and fifty yards from this point another body of ore has been developed by a rather shallow open cut. The exposure shows a fairly rich ore cropping to the surface, a considerable portion of it being wash ore. Thus far but little ore has been mined from this opening. This is known as the "Second Vein."

A third deposit (known as the "Third Vein") has been opened up on the face of a ridge some five hundred yards to the S. S. E., and about one mile east of the Shenandoah Valley Railroad. The bank exhibits a series of narrow, shallow trenches and some test pits covering an area of one hundred and fifty by forty feet. Ore comes practically to the surface; and the developments show for the most part solid lump ore. A sample, consisting of one hundred and thirty-three pieces, was selected from different openings from ore in place. It shows on analysis:

Metallic iron,	51.450
Phosphorus,	.328
Silicious matter,	12.480
Phosphorus in 100 parts iron,	.637

The old Buena Vista furnace is now in ruins, having been destroyed during the late war; but it is said to have produced an excellent quality of charcoal pig iron. The flux used was a "marl," found in great quantity on the property, and easily mined. From a deposit fully forty feet thick, occurring at Marl Branch where it crosses the Lexington turnpike, a sample was selected for analysis. It yields:

Carbonate of lime,	95.178	
Carbonate of magnesia,	1.553	
Sulphate of lime,	.058=	.014 sulphur.
Phosphate of lime,	.039=	.008 phosphorus.
Oxide of iron and alumina,	.240	
Water and carbonaceous matter,	1.942	
Silica,	.990	
	100.000	

It is surprising that an article so pure as this is, and one which can be so easily and so cheaply mined, has not been more extensively used by burning it for agricultural purposes or for such other purposes as lime may be used. There are other large deposits of this "marl" along the line of the Shenandoah Valley Railroad; and it would well repay the farmers to make occasional use of it, especially on the bottom lands. The benefits derived from a judicious use of lime on land are too well-known to need mention here.

Glenwood Estate.

Iron ore has been developed on this property and successfully worked for many years to supply the stock of the Glenwood furnace. The principal opening, known as the *Greenlee mine*, is situated about one mile from the Shenandoah Valley Railroad where it crosses the James river. It consists of an irregular-shaped open cut two hundred feet long, sixty feet wide and forty feet deep, with an average of about ten feet of stripping. The bank has not been worked for five years, and the faces are now much covered with wash. An occasional boulder of a rich-

looking ore is still exposed in the sides of the bank. The "strike" of the ore-bed is north-east and south-west; and it has been proven by shafts and cuts in the latter direction for a considerable distance. The bank yields about one third lump-ore—full of little drusy cavities lined with quartz crystals. Elk Creek furnishes an abundant and permanent supply of water for washing purposes. The washer is located here, three hundred yards from the furnace, which is three-fourths of a mile from the ore bank. The furnace stack is 33×8½ feet, rebuilt in 1874, but at present out of blast. A sample of the ore, two hundred and ten pieces was selected from a small pile at furnace to represent the lump and wash ore. It yields on analysis:

Metallic iron,	47.750
Phosphorus,	.314
Silicious matter,	18.630
Phosphorus in 100 parts iron,	.657

The Mountain bank, situated two miles south-east of the Shenandoah Valley Railroad, has also furnished a considerable amount of ore; but it is now so completely filled up that the actual depth of ore mined cannot be stated. It is said to have yielded ore of the same character as the Greenlee mine.

Other developments showed the same general features, so that no useful description can be given of them. The "pipe ore bank," near the furnace, is said to have yielded a considerable quantity of rich brown hematite ore.

Red hematite has also been developed on this property in a bed four feet thick on Skillern mountain, three-fourths of a mile from the Shenandoah Valley Railroad. It has been uncovered for a length of seventy-five feet. Analyses have been made of it showing 50 per cent. metallic iron; but a sample, consisting of seventy pieces selected from ore in place, yielded:

Metallic iron,	21.250
Phosphorus,	.180
Silicious matter,	62.950
Phosphorus in 100 parts iron,	.847

Botetourt County.

Arcadia Furnace Property.

At no other point examined has the development of the *red hematite ore* (the specular ore of the Blue Ridge) been so extensive or satisfactory as on the Arcadia furnace property. It has been opened up at numerous points for several miles showing the same general character of ore in beds varying from eighteen to forty-eight inches in thickness. The ore occurs between walls of sandstone and slate; and as the beds are cut across by numerous ravines, natural openings are afforded for mining operations, either by open cut or tunnel. At the outcrop the ore is sometimes very silicious—full of little grains of quartz—but this feature generally diminishes as the ore gets well under cover. It mines in square blocks, so that it can be handled at a minimum cost.

The ore occurs in several separate and distinct beds; but how many there are and what the geological relations are, it does not come within the province of this report to discuss.

As the various developments show generally the same features, it will only be necessary to describe a few of the openings. The ore has been exposed by tunnel and open cut at numerous points along the Buchanan and Peaks of Otter turnpike. At a distance of nearly three miles southeast from Buchanan, "Tunnel No. 1" has been driven in the hillside for a distance of forty feet, showing the ore bed thirty-four inches thick, with walls of sandstone and shale. About two hundred yards further above, "Tunnel No. 2" has been driven in for sixty-six feet, showing the ore twenty inches thick at the outcrop. A short distance further—about three and one-half miles from Buchanan—"Tunnel No. 3" presents the same general features. The character of the ore at this point is shown by the following analysis of a sample consisting of sixty-three pieces selected from small pile at roadside:

Metallic iron,	43.300
Phosphorus,	.468
Silicious matter,	30.540
Phosphorus in 100 parts iron,	1.080

Four miles south-east from Buchanan and about four hundred yards from the Buchanan and Peaks of Otter turnpike, the ore has been opened up quite extensively and several thousand tons of it have been mined. This is known as the *Pollard cut.* The development has been made on both sides of the ravine, and shows the ore bed forty-three inches thick. Here the formation is much distorted; and on the south side of the ravine the ore shows in a double-fold, standing nearly vertical at the outcrop. The wall-rock is a loose, friable slate or shale. A sample, consisting of ninety-seven pieces, was selected from the large ore pile as mined; but a more careful sorting of the ore would doubtless show better results. The analysis yielded:

Protoxide of iron,	1.221
Sesquioxide of iron,	55.928
Sesquioxide of manganese,	.043
Alumina,	1.808
Lime,	.730
Magnesia,	.706
Sulphuric acid,	.007
Phosphoric acid,	.607
Water,	3.144
Silicious matter,	35.690
	99.884
Metallic iron,	40.100
Metallic manganese,	.030
Sulphur,	.003
Phosphorus,	.265
Phosphorus in 100 parts iron,	.660

Another opening has been made four and one-half miles from Buchanan and about forty yards from the turnpike. Here the ore has been worked by open cut, and the exposure shows a bed twenty-one inches thick, with loose friable shale as a wall-rock. A sample, seventy pieces from pile at roadside, shows the ore at this point to contain:

Metallic iron,	41.400
Phosphorus,	.257
Silicious matter,	33.260
Phosphorus in 100 parts iron,	.620

At the junction of the North Branch with Jennings' Creek, one-fourth mile distant from the old blast furnace, the ore has again been opened up for a few yards, showing a bed eighteen inches thick of the same general character of ore, between sandstone and slate walls.

These numerous openings seem to establish the continuity of the ore beds over a large area; and as the ore can be cheaply mined, it will doubtless prove valuable to mix with the less silicious brown hematites. The ore occasionally—even when it is very compact—carries a few lenticular masses of slate or shale; but generally the impurity is in the form of fine grains of quartz.

Valuable deposits of brown hematite ore are also said to occur on this property, but these were not examined.

Purgatory Iron property.

Although there are several important ore developments reported on this property, my attention was only directed to one, viz: the *May's Mountain bank*, just being opened up two and one-half miles from the Richmond and Allegheny Railroad and about nine miles north-west of Buchanan. The present exposure shows some twenty feet of ore-bearing clays. The deposit is being worked by open cut, and in it a considerable face of lump ore is exposed. But the bank will probably not average more than one-third lump ore. A sample, one hundred and twenty-six pieces, was selected from pile at mouth of drift to represent the *lump* ore. It yields:

Metallic iron,	42.200
Metallic manganese,	3.825
Phosphorus,	.108
Silicious matter,	19.830
Phosphorus in 100 parts iron,	.255

Houston Mines.

Near Houston station, on the line of the Shenandoah Valley Railroad, the Crozer Steel and Iron Company are mak-

ing extensive developments of iron ore with a view to supply their new furnace now being erected at Roanoke. These are known as the *Houston mines*, and consist of a series of openings numbered one to six, covering a territory over six hundred yards in length.

These mines are now much more fully opened, and have yielded up to this time over 30,000 tons of ore, all of which has gone to the Crozer furnace at Roanoke. The manganiferous iron ore which occurs in these mines in irregular deposits has been used by the Cambria Iron Company at Johnstown, Pennsylvania.

"*No. 6 opening*" is situated about one mile south from Houston station. It consists of an open cut seventy-five feet long, twenty-five feet wide, showing a breast of ore-bearing clays fifteen feet thick, with an average over-burden of about thirteen feet. The yield of lump ore is about one-third. The cut is fifteen feet lower than the lowest level of No. 5 next to be described.

"*No. 5 opening*" is eighty feet long, seventy-five feet wide and twenty-five feet deep, with a lower level fifty by fifteen by fifteen feet. The ore occurs in variegated clays, sometimes quite rich; while on the other hand, horse-backs of clay frequently come in carrying but little ore. Thus far no ore has been washed in the regular way; but experiments have been made which show that the ore material will average about one-half clean ore. Occasional boulders of rich lump ore—often bomb-shell ore—show in the faces of the cut, and the bank at this point will average one-third ore of this kind—both openings showing the same general character. Samples, one hundred and thirty-eight pieces, were selected to represent the *lump ore* from these openings, from one pile of ore from No. 6 and two from No. 5. The results of the analysis are as follows:

Protoxide of iron,	Trace.
Sesquioxide of iron,	74.571
Sesquioxide of manganese,	2.038
Sesquioxide of cobalt,	None.
Oxide of zinc,	None.
Alumina,	.951
Baryta,	.040

Lime,	.550
Magnesia,	.356
Sulphuric acid,	.040
Phosphoric acid,	.444
Water,	10.822
Silicious matter,	10.450
	100.262
Metallic iron,	52.200
Metallic manganese,	1.419
Sulphur,	.016
Phosphorus,	.194
Phosphorus in 100 parts iron,	.371

"*No. 4 opening*" lies one and a quarter miles from Houston station, and one thousand four hundred feet from No. 5. The bank is developed by open cut and tunnel, the cut being seventy-five feet long, thirty feet wide and fifty feet deep, with an average of twelve feet overburden. This cut is on a level one hundred and seventy-seven feet lower than No. 5. Here the ore is highly manganiferous; and at some points it shows quite a pure manganese ore. The proportion of lump ore is about two-thirds. No ore has yet been washed. The ore-bearing clay is generally of a red color.

Two tunnels driven in an east and west direction for 40 feet each way show practically the same conditions as in the open cut; and a third tunnel across the measures shows the deposit to be at least ten feet wide. Ore comes near the surface at some points in the bank; but the average amount of stripping will not be far from 12 feet. Samples were selected from ore piles, as follows:

No. 1, one hundred and fifteen pieces, to represent the *iron ore.*

No. 2, sixty-eight pieces, to represent the *manganiferous iron ore.*

They yielded respectively the following:

	No. 1.	*No. 2.*
Metallic iron,	47.150	12.325
Metallic manganese,	7.277	44.312
Phosphorus,	.061	.101
Silicious matter,	8.030	5.470
Phosphorus in 100 parts iron,	.129	

Since the bank has been further developed, samples were selected by Mr. H. M. Curry of the Edgar Thompson Steel Company, Pittsburgh, as follows:

No. 3, average of the stock pile.

No. 4, selected manganese ore.

The analyses of these samples, which are here given by permission, show:

	Average.	*Selected.*
Metallic iron,	29.110	0.500
Metallic manganese,	24.710	59.870
Phosphorus,	.138	.049
Silica,	7.770	2.300

"*No 3 opening*" is about one hundred and fifty-two feet south from No. 4, and seventy-seven feet higher up the mountain slope. It consists of an open cut fifty feet long, twenty feet wide and twenty feet deep. The average overburden is not over five feet. The bank yields about one sixth lump ore of the same general character as that in No. 5. The ore-bearing clays are red in color, and they preserve this feature in the next two openings.

"*No. 2 opening*" is one hundred and sixty-five feet from No. 3, and consists of a small open cut and shaft, the latter seventy feet deep, with ore material for forty feet. Ore comes to the surface. Some of it shows a little manganese; but generally it is similar to that in No. 5 opening.

"*No. 1 opening*," a small shallow cut, is two hundred and thirty-one feet from No. 2. The ore comes to the surface, and is generally redder in color and somewhat more shaly in character than at any of the other openings. The proportion of lump ore is about one-sixth. The general direction of these openings from No. 6 to No. 1, is south 83½° west. A washer is being erected convenient to all the openings. It is located one and one-fourth miles from Houston station. Brough's Run, a small stream in the vicinity, will furnish the water supply for washing purposes.

Other developments have been made by the Crozer Steel and Iron Company since the date of my visit; and at my request Captain Le Warne, superintendent of the mines, selected samples of the ore for analysis. *The Murray bank opening No. 1*, is situated near Troutville and one and one-half miles from the Shenandoah Valley Railroad. It consists of an open cut 50×20×20 feet, "with good prospects for a large output of ore." The sample of the ore consisted of twenty-five pieces, and yielded on analysis:

Metallic iron,	53.050
Phosphorus,	1.266
Silicious matter,	6.630
Phosphorus in 100 parts iron,	2.386

On Jacob G. Layman's farm, (which was part of the original Cloverdale furnace property,) about a quarter of a mile south from the Shenandoah Valley Railroad at Troutville, a considerable development of iron ore has been made. The *main cut* is opened in the face of a ridge about three hundred yards east of the old Cloverdale or Fincastle road. The opening is one hundred and fifty feet wide, two hundred and fifty feet long and fifty feet deep. The ore occurs in variegated clays, coming close to the surface. Occasional masses of a good rich-looking ore may be seen in the faces of the cut, but generally the ore material is covered up by a wash. Quite a good deal of wash ore, however, shows all around the outside of the cut. A sample, one hundred and fifty-seven pieces, selected to represent the lump and clean wash ore from the entire face of the cut, yields:

Metallic iron,	42.750
Phosphorus,	.076
Silicious matter,	25.000
Phosphorus in 100 parts iron,	.177

In an E. N. E. direction, for a quarter of a mile or more the deposit has been proven at several points by small open cuts in the face of the ridge; and at a point about a quarter of a mile south-east from Troutville, it has been opened up by a large irregular-shaped cut, from which a good deal of

ore has been mined. It presents here the same general appearance as at the main cut, the ore occurring in variegated clays and sometimes showing in boulders of considerable size in the faces of the cut.

Below the *main cut* about seventy-five yards, there is another opening, now much fallen shut, about one hundred and twenty-five feet long and seventy-five feet at the widest point. Here the ore occurs in a loose, granular, red clay. An outcrop of rich wash ore extends from this point to the old Cloverdale road where solid ledges of limestone come in and practically limit the deposit in this direction. The ore is a rich-looking brown hematite, with but little flint. An occasional sandy piece may be seen, but this character is not prominent. Another opening near this shows the same general character of ore. Buffalo Creek, at Troutville, affords a permanent water supply for ore-washing purposes. A sample of the ore, consisting of two hundred pieces selected from south face of cut, yields:

Metallic iron,	**49.575**
Phosphorus,	**.167**
Silicious matter,	**14.920**
Phosphorus in 100 parts iron,	**.336**

Section II.

Mines along the main line of the Norfolk & Western Railroad.

Numerous causes have combined of late years to increase largely the production of iron ore along the main line of the Norfolk & Western Railroad. The recent erection of the large blast furnace at Roanoke has created a demand of from 200 to 250 tons of iron ore daily; and in addition to this permanent demand there have been shipped to Pennsylvania and other markets varying quantities of ore.

The Crozer Steel and Iron Company's furnace at Roanoke has been in blast for a little over a year, with a daily output of about 100 tons of pig metal.

The furnace was built under the direction of Messrs. Witherow & Gordon of Pittsburgh, Pa. Building was begun

in April, 1882, and finished May 1, 1883. The furnace was blown in May 28. The stack is 70 by 16; hearth, 9 feet diameter; tunnel-head, 12 feet 8 inches; columns, 20 feet above hearth-level, below which they extend 2 feet. The shell or casing is 23 feet diameter at bottom, and 19 feet at top. Double bell, 8 feet 4½ inches external diameter, and 4 feet 4 inches internal diameter, operated by a 32-inch by 63-inch air-lift, provided with safety catch-rods. The tuyeres are seven in number, with 7-inch nozzles placed 5 feet 6 inches above hearth-level. The furnace is provided with three Whitwell fire-brick hot-blast stoves, 18 feet diameter and 70 feet high, each containing over 20,000 square feet of heating surface. The iron chimney draught-stack is 160 feet by 8 feet. There are ten steel flue boilers; and two Weimer blowing-engines, with steam cylinder 42 inches and 4-foot stroke, and blowing cylinder 84 inches with 4-foot stroke, and each capable of blowing 12,000 cubic feet of air per minute. The steam-hoist is the Crane Brothers' pattern. The stock-house is 75 feet by 150 feet, frame; cast-house, 138 feet by 50 feet by 28 feet, brick with corrugated iron roof. The engine house is roofed with a sway-bottom iron water-tank 6 feet deep in center.

Bedford County.

The Crozer Steel and Iron Company are now developing, on the Edith iron property, two ore banks known respectively as the *Buford* and *Cundiff*. These are situated about two miles from Blue Ridge Springs on the Norfolk and Western Railroad.

Capt. LeWarne, superintendent, supplies the following information, with samples of the ores:

Buford bank consists of a series of five openings, the largest being 75×33×23 feet, and the smallest 45×20×15 feet. The sample received consisted of forty-five pieces, from four openings. It yields on analysis:

Metallic iron,	52.850
Phosphorus,	.568
Silicious matter,	8.390
Phosphorus in 100 parts iron,	1.074

The *Cundiff bank*, (*brown hematite*,) consists of three openings, the largest being 64×53×20 feet. A sample of the ore, thirty-six pieces from two openings, shows the following:

Metallic iron,	54.600
Phosphorus,	.594
Silicious matter,	5.570
Phosphorus in 100 parts iron,	1.088

The *Cundiff bank* (*red hematite*) consists of two openings, 18×12×7 feet, and 42×28×14 feet. A sample of the ore, thirty-one pieces from both openings, yielded:

Metallic iron,	46.700
Phosphorus,	.666
Silicious matter,	24.750
Phosphorus in 100 parts iron,	1.426

These are now known as the "Upland mines" of the Crozer Steel and Iron Company; they have been very much enlarged and are now yielding 150 tons daily for their furnace supply. The Company have already worked out over 45,000 tons of ore from these mines, and Col. Houston, general manager, reports them as now looking well for future economical and extensive working.

Roanoke County.

On the property of *McLanahan, Rorer and Chapman*, (now owned and operated by the Rorer Iron Company,) two and one-half miles south of Roanoke, an extensive body of iron ore is now being opened up. The present exposure, on the north slope of Mill Mountain, consists of an open cut forty feet long and eight feet wide, showing at the end of the cut a face of fourteen feet of a rich-looking, somewhat cellular, yellowish-brown iron ore. This is known as "*No. 2 cut.*" Several other openings near this show the same general character of ore, and the indications are all favorable for a large deposit of it. A sample, eighty-three pieces selected from ore pile at mouth of cut, yields on analysis:

Metallic iron,	52.425
Phosphorus,	.493
Silicious matter,	9.610
Phosphorus in 100 parts iron,	.940

On the top of the ridge, two hundred and fifty yards from the "No. 2 cut" and one hundred and sixty-two feet in elevation above it, there is another development known as "*No. 3 opening.*" It consists of an open cut 20×15 feet, showing a nearly solid face of ore. Generally the ore is much more compact than the other, and it has a dark brown color, sometimes almost black. A sample, ninety-six pieces, was selected from ore pile at mouth of cut. It shows:

Metallic iron,	55.350
Phosphorus,	1.260
Silicious matter,	3.870
Phosphorus in 100 parts iron,	2.276

Since the first examination of this property was made there has been sufficient development to fairly show the large ore producing capacity of the property. Some 12,000 tons of good ore have been shipped from the different openings, and this amount of development has laid bare an extensive face of lump and wash ore which can be economically worked, and from which an increased production can be rapidly made whenever the market shall justify it.

A narrow gauge road connects the mines with the main line of the Norfolk and Western Railroad south of Roanoke, thereby securing ample facilities for handling and shipping the ore on an extensive scale.

Three and one half miles S. S. W. of Roanoke, *Messrs. Rorer & Chapman* have opened up on their property (formerly the Gale farm) quite a promising body of ore; but a sufficient amount of work has not yet been done to justify any positive conclusion as to the extent of the deposit. The opening, known as "*No. 1 opening,*" lies on the east face of a ridge. The present face shows ten feet of ore uncovered; but portions of it are more or less mixed with silicious matter and sometimes clay. A sample, consisting of seventy-five pieces, was selected from ore in place

across the face of the cut to represent the *clean ore*. An analysis shows it to contain:

Metallic iron,	56.550
Phosphorus,	.178
Silicious matter,	5.710
Phosphorus in 100 parts iron,	.314

Pulaski County.

Clayton's Property.

The *Honaker bank*, on the property of S. S. and J. E. Clayton, is situated one and one-half miles south-east from Pulaski on the Norfolk and Western Railroad. The bank has been developed by cross cuts and shafts. The cross cuts extend over the south-east face of a ridge for a distance of at least one thousand one hundred feet. The ore shows in a bold outcrop all the way between the cuts, sometimes in large boulders weighing a ton or more. The general character of the outcropping ore is that of a rich-looking, cellular brown hematite. As exposed in one of the cuts the bed shows for a width of seventy-five feet; but in mining there would probably be rejected about twenty-five feet, thus making a working face of fifty feet of ore. The leaner ore is generally cherty, occasionally showing some flint. The cross cut shows that while the ore comes practically to the surface at a great many points, yet there would be an average of three or four feet of over-burden to be removed. The indications point to there being a considerable body of ore at this point. The Norfolk and Western Railroad can be reached by easy grade over a well-prepared road, the distance being seven thousand two hundred feet from ore bank. A sample of one hundred and forty-three pieces taken from the face of several cross cuts will fairly represent the shipping ore. The analysis shows it to contain:

Protoxide of iron,	None.
Sesquioxide of iron,	69.107
Sesquioxide of manganese,	.783
Sesquioxide of cobalt,	.090
Oxide of zinc,	.050
Alumina,	1.511
Lime,	.520

Magnesia,	.425
Sulphuric acid,	.177
Phosphoric acid,	.252
Water,	11.670
Silicious matter,	15.400
	99.935
Metallic iron,	48.375
Metallic manganese,	.511
Sulphur,	.071
Phosphorus,	.110
Phosphorus in 100 parts iron,	.227

The *Martin bank*, on the same property, is situated half a mile south-east from Pulaski station. The ore has been developed by a cross cut along the edge of a narrow ravine. The face is now considerably covered by wash, but quite a rich-looking mass of ore, probably ten feet thick, may still be seen. The deposit has been tested in an E. S. E. direction for several hundred feet, with a fairly rich ore showing in some of the pits; and the outcrop is quite pronounced at several points. The ore is more compact and fine-grained than at the Honaker bank. A sample, one hundred and seventy-five pieces selected from a pile of twenty to twenty-five tons of ore, yields:

Metallic iron,	51.850
Phosphorus,	.321
Silicious matter,	9.800
Phosphorus in 100 parts iron,	.619

SECTION III.

Ores Tributary to the New River Division of the Norfolk and Western Railroad.

Between the New River Division of the Norfolk and Western Railroad and the East River Mountain in Tazewell county, there is a long line of brown hematite ore deposits running nearly parallel to the railroad, and about a mile from it at the nearest point. This outcrop has been prospected by numerous small open cuts and test pits for a distance of nearly 15 miles along what are locally known as Taylor's Ridges. The ore seems to be deposited, to a great extent,

along the line of a large fault—where the Devonian slates and sandstones abut against the Lower Silurian limestones. In these latter there are several promising deposits which, however, have been as yet but little developed. The opening of the New River Division and the proximity of these ores to the Flat Top coal field will doubtless ensure their speedy development.

The following analyses will illustrate the general character of the ores:

Tazewell County.

Gid. Billips.

On the Gid. Billips property, 5 miles south-west from Graham, ore has been developed near the summit of a ridge by an open cut about 75 feet long, showing a bed of ore from 4′ to 6′ in thickness. The ore has simply been uncovered, showing itself at points strongly impregnated with sandrock; but the indications are that this feature is confined to the surface ore, and that the quality will improve in deeper workings. Indeed, this has already been proven to be the case, for a shaft sunk to a depth of 12 feet shows the ore comparatively free from sandrock and chert. The ore sometimes crops to the surface, but there will be perhaps an average of three feet of over-burden. A sample, 102 pieces taken from the ore in place, yields on analysis:

Metallic iron,	43.850
Phosphorus,	.242
Silicious matter,	23.100
Phosphorus in 100 parts iron,	.551

A second sample, 28 pieces taken from where the ore seems free from sandrock, yields:

Metallic iron,	50.750
Phosphorus,	.275
Silicious matter,	11.860
Phosphorus in 100 parts iron,	.541

Carter-Billips.

On this property, on a continuation of the same ridge, 5¼ miles south-west of Graham, the ore has been uncovered for

about 30 feet, showing 6′ of ore of the same general character as on the Gid. Billips property, although at this point it is not so much impregnated with sandrock near the surface. A sample, 104 pieces taken from ore in place along the cut, shows:

Metallic iron,	49.750
Phosphorus,	.167
Silicious matter,	15.370
Phosphorus in 100 parts iron,	.335

Champ Property.

On the Champ property, lying 1½ miles N. W. from Springville, 9 miles S. W. from Graham and about 3 miles S. W. of the Gid. Billips opening, ore has been uncovered for 100′ in length. It varies in width from 2′ to 5′, with an average of about 3½ feet. The character of the ore is very variable; sometimes it is dark brown in color; again, yellowish brown and brick red. At points in the cut a lean shaly ore comes in, carrying about 30 per cent. metallic iron. A sample, 135 pieces taken from ore in place along the entire length of the cut, and including all the varieties, yields on analysis:

Metallic iron,	42.725
Metallic manganese,	.972
Phosphorus,	.150
Silicious matter,	22.730
Phosphorus in 100 parts iron,	.351

Rose Property.

On this property, 1 mile N. W. from Springville and 9 miles S. W. of Graham, an abundant outcrop of a reddish brown ore is found covering an area of about 8 acres on the south slope of a ridge. No developments have yet been made. A sample, 125 pieces of the surface ore shows:

Metallic iron,	51.700
Phosphorus,	.043
Silicious matter,	11.730
Phosphorus in 100 parts iron,	.083

Harman property.

On the Harman property, lying 8 miles S. W. from Graham, a bold outcrop or float of ore covers the north slope of a ridge for a quarter of a mile or more. A drift about 12′ deep shows for the first 5 or 6 feet quite a good deal of loose lump ore in a granular clay ; then a stiff yellow clay with apparently not so much ore. A shaft at this point has gone down 40 feet, showing more or less ore in clay all the way from surface down ; but no solid body of ore has yet been encountered. Sometimes the ore occurs in bombs, which on being broken are found quite frequently to hold considerable iron pyrites. The character of the float ore is the same as that found in the trial shaft from which the sample, 53 pieces, was taken. It yields on analysis :

Metallic iron,	55.225
Phosphorus,	.029
Silicious matter,	9.380
Phosphorus in 100 parts iron,	.052

Faulkner property.

This property lies 9 miles S. W. from Graham and about 1 mile N. W. from Springville. No developments have yet been made. A heavy outcrop of a rich-looking cellular brown hematite ore covers an area of about 5 acres.

A sample, 65 pieces, of the surface ore shows it to contain :

Metallic iron,	55.250
Metallic manganese,	1.657
Phosphorus,	.087
Silicious matter,	5.840
Phosphorus in 100 parts iron,	.157

Graham–Smoot property.

No developments have yet been made on this property. It lies about 10 miles south-west from Graham. On the north slope of the "Harman Ridge" an abundant outcrop extends in a N. E. and S. W. direction for 200 yards or more, showing invariably a rich dark brown hematite, often full

of little cells lined with fibrous ore. A sample, 115 pieces, was taken over a considerable area. It yields on analysis:

Metallic iron,	56.100
Metallic manganese,	1.866
Phosphorus,	.111
Silicious matter,	4.120
Phosphorus in 100 parts iron,	.197

SECTION IV.

Red Hematite and Magnetic Iron Ores in the Lower Silurian Limestones in South-west Virginia and Tennessee tributary to the Norfolk and Western Railroad system.

These ores form a most interesting group almost unique in character, and for that reason it has been thought best to include them in a separate section, although the developments are wide apart.

They have been opened up at various points, sometimes showing in the same mine *red* and *brown hematite* with *magnetic iron ore;* but wherever they have been found they show an ore remarkably rich in metallic iron and invariably low in phosphorus—practically in every case being suitable for the manufacture of Bessemer pig-iron. Sometimes the ore shows a dense fine-grained red hematite; and it possesses this feature in many of the openings which promised a valuable deposit; but, owing to the difficulty in smelting it in the small cold-blast charcoal furnaces, the workings were abandoned and are now practically fallen shut. There would, however, be no difficulty in reducing these ores in the large modern coke furnaces.

The recent successful development of a large body of ore by the Southwest Virginia Improvement Company near Pearisburg, Giles county, Virginia, leads to the hope that many of the other deposits will receive the attention which the richness and great purity of the ores seem to warrant.

It may prove interesting to note that at nearly every opening examined iron pyrites was noticed, yet in no case does the ore itself carry an appreciable amount of sulphur; but

the occurrence may have some bearing on the origin of these ores. Wherever the red and brown hematites are found together they are equally low in phosphorus, and this fact may be suggestive of a common origin.

Giles County.

The Ripplemead or Johnson mine is situated four miles E. N. E. of Pearisburg, on the New River Division of the Norfolk and Western Railroad, and is now being quite extensively worked by the Southwest Virginia Improvement Company. The ore outcrops on the east bank of New River. A seemingly solid mass of it has been uncovered for a length of seventy-five feet and a width of forty feet at water level. A coffer-dam has been built eight feet high above the present outcrop in the bed of the river, and two hundred and seventy feet long, with ends fifty-two feet long, inclosing the mine and keeping it almost free from water. A diamond drill hole is said to have gone through one hundred and fifty feet of ore, with occasional ledges of limestone coming in. Several thousand tons of the ore have already been mined and shipped to Harrisburg and other points, and the deposit promises to be quite an extensive one. Back from the river bed, the ore is covered with an average of eleven feet over-burden, consisting chiefly of soft sand with occasional limestone boulders. The ore consists for the most part of magnetic oxide of iron. At some points it carries small lenticular masses of slate, and generally it is highly impregnated with carbonaceous matter. *Fluor-spar* has been noticed in small quantities in the ore at some points in the bank.

A sample, consisting of five hundred and eighty-three pieces, was selected from several piles of *lump ore* at the mine. It yielded on analysis:

Metallic iron,	**63.550**
Sulphur,	**.002**
Phosphorus,	**.051**
Silicious matter,	**5.210**
Phosphorus in 100 parts iron,	**.080**

The *Pack's Tunnel mine* is situated two and one half miles E. S. E. of Pearisburg. It has been developed by open cut, tunnel and exploratory shaft. From the open cut nearly two thousand tons of ore have already been taken, consisting chiefly of brown hematite with occasional pieces of red hematite.

From the top of the hill where outcrop of ore shows itself, the open cut has been carried to a depth of nearly fifty feet, from which point the ore has been mined; and from the level of this, a shaft has been sunk to a depth of nearly eighty feet through a similar stratum, with a rather more plentiful show of ore. The shaft is still being proceeded with, although a few boulders of limestone have been encountered. The tunnel has simply pierced into and not through the side wall of the mass, at a level of about forty feet from the top of the hill.

Probably two thirds of the ore will require washing. Walker's Creek flows along the foot of the hill, about two hundred and fifty feet below the ore deposit, affording an abundant and never-failing supply of water. A sample, two hundred and fifty-four pieces, of the *brown hematite lump ore* shows the following:

Metallic iron,	48.825
Sulphur,	.162
Phosphorus,	.054
Silicious matter,	19.760
Phosphorus in 100 parts iron,	.110

The Chapman development lies on a line between the Pack tunnel and Ripplemead mines, and on the same strike of the strata. A shaft on top of the hill has been sunk to a depth of eighty feet, showing some fairly rich pieces of red and brown hematite ore; but most of the material from the shaft consists of a slaty iron ore mixed with limestone. At a lower level on the face of the hill, a tunnel has been driven in with the intention of proving whether the outcrop, as shown at the surface, develops into a solid body of ore at a greater depth.

Near Newport, on the *Sinking Creek furnace property*, a deposit of red hematite has been partially developed by three or four small and narrow open cuts in the face of a hill about two hundred yards above Sinking Creek. The bank is known as the "*Price bank.*" The ore is found scattered along a seemingly well-defined area for one hundred and fifty yards or more, beginning a short distance above the creek and running with the trend of the limestone rocks.

In the bottom of one of the open cuts a shaft is said to have been sunk ten feet in solid ore; but it is now fallen shut. Probably a thousand tons of ore have been mined from the several open cuts, but no work has been done for the last fifteen months. Wherever seen, the ore shows a rich red hematite—often the specular variety. Samples, one hundred and ninety pieces from the different openings, were analyzed with the following result:

Metallic iron,	61.000
Phosphorus,	.028
Silicious matter,	7.610
Phosphorus in 100 parts iron,	.046

Washington County.

The *Golleher bank* is opened up four miles from Abingdon, and one and one half miles from the Norfolk and Western Railroad. The development consists of an irregular-shaped shallow open cut covering an area of 120×40 feet. At several points in the bank cherty ledges of limestone come in and cut the ore out, so that it is impossible at present to give the actual thickness of the ore. In the bed of a small scantily-fed stream, now entirely dry, the ore shows at the surface, and it has been opened up on both sides of the creek. Sufficient work has not yet been done to thoroughly test the extent of the deposit, and only a few hundred tons of the ore have been mined. Sometimes it shows a rich magnetic iron ore containing probably sixty to sixty-five per cent. metallic iron, while again, it is often more or less intimately mixed with slaty material and some calcareous matter. An occasional mass of rich *red hematite*

may be seen, but generally this feature is not very pronounced—the bulk of the ore being *magnetic oxide of iron* Samples, four hundred and eighty-five pieces, were selected from the three ore piles at the bank, to represent the ore that has been taken out; but by rejecting the slaty material in mining, an ore much richer in iron could be obtained. The analysis shows the following result:

Protoxide of iron,	12.117
Sesquioxide of iron,	66.607
Sesquioxide of manganese,	None.
Alumina,	2.197
Lime,	1.890
Magnesia,	1.982
Sulphuric acid,	.150
Phosphoric acid,	.082
Carbonic acid,	1.806
Water and carbonaceous matter,	5.458
Silicious matter,	7.760
	100.049
Metallic iron,	56.050
Metallic manganese,	None.
Sulphur,	.060
Phosphorus,	.036
Phosphorus in 100 parts iron,	.064

At the *Ricketts opening*, situated five miles from Abingdon, an occasional ball or boulder of a rich *red hematite* has been found in a stiff yellowish-red clay; but no body of ore has yet been proven. The development consists of a narrow cut thirty-five long and twenty feet at deepest point, with work going on at date of visit.

The "Preston or Grey opening" lies six miles south-east from Abingdon and about two hundred yards south-east from the South Fork of the Holston river. But little work has as yet been done here. Limestone rocks show in bold cliffs on both sides of a narrow ravine, in the precipitous faces of which occasional lenticular masses of red hematite are exposed.

Starting at the level of the ravine near a small creek, a narrow cut has been made running in under a limestone

cliff for a short distance and exposing a ledge of solid fine-grained red hematite probably two feet thick; but the opening was partially filled with water, and no accurate measurements could be made. At this point the rocks are much disturbed and broken, and the present developments are in such an unsatisfactory condition that it is difficult to judge of the prospects for ore; but the present outlook is not especially encouraging for mining cheap ore. A sample of the ore, thirty eight pieces, shows the following analysis:

Metallic iron,	59.150
Phosphorus,	.049
Silicious matter,	7.880
Phosphorus in 100 parts iron,	.083

The *McDaniel bank* is situated about seven miles south from Montgomery Switch, N. & W. R. R. Ore outcrops a few yards above Spring Creek on its north-east side, and it has been partially developed by a narrow shallow cross cut, about four feet at deepest point. The ore occurs in a yellowish-red clay in nodules and streaks; but thus far no solid mass of it has been found. The general character of the ore is a rich-looking *red hematite;* and at some points in the cut it shows *brown hematite.*

An outcrop of the same character of ore is said by Mr. Garth to occur on his farm, about a mile north-east from this opening; and as the general strike of the limestone is here north-east and south-west, this may represent a continuation of the same deposit.

A sample of the ore, one hundred and thirty-five pieces, from a small pile taken out of the *McDaniel opening*—representing both the *red* and *brown hematite*—yields:

Metallic iron,	57.375
Phosphorus,	.020
Silicious matter,	7.900
Phosphorus in 100 parts iron,	.034

Sullivan County, Tenn.

The *Sharp bank* lies eight and one-half miles from Bushong Switch, E. T., Va. & Ga. R. R., and ten miles south-east from Bristol. Both red and brown hematite ore have been

developed here. An open cut seventy feet in diameter has yielded a good supply of brown hematite, principally wash-ore; and a considerable show of wash-ore may yet be seen on the sides of the bank.

A trench about fifty feet long and fifteen feet wide, between nearly vertical ledges of limestone, is said to have developed a bed eight to ten feet thick of solid *red hematite*. But the workings are now filled with water, and no part of the bed can be seen. Thin streaks of ore show in the limestone faces, and occasional pieces may be found lying around the bank. Samples, sixty-four pieces selected from these, yield:

Metallic iron,	65.550
Phosphorus,	.026
Silicious matter,	2.970
Phosphorus in 100 parts iron,	.039

Through the courtesy of Mr. H. M. Curry of Carnegie Bros. & Co., Pittsburgh, I am permitted to use the following, from a private letter dated November 17, 1882: "I took two samples from the *Garrett place*, north-east from the Sharp bank, which I believe you did not visit. They consisted of probably fifty to seventy-five pieces each. The results of our analyses are as follows:

	Red hematite.	*Brown hematite.*
Iron,	66.470	56.030
Phosphorus,	.032	.023
Silica,	2.920	6.810
Phosphorus in 100 parts iron,	.048	.041

About a mile from the Sharp bank, the *Cowan or Lowry bank* shows a small open cut, twenty feet in diameter and ten feet deep. An abundant outcrop of rich brown hematite ore shows for several hundred feet all around the open cut. No *red hematite* was seen here, but the developments have not yet been sufficient to test the deposit. Cold Spring Creek, a quarter of a mile distant, would afford a sufficient supply of water for washing purposes. A sample of the ore, thirty-two pieces, shows the following:

Metallic iron,	57.625
Phosphorus,	.029
Silicious matter,	3.710
Phosphorus in 100 parts iron,	.050

The *Thomas bank* is situated seven miles S. S. E. of Bristol and five miles from Bushong Switch. It exhibits a cut fifty feet long, twenty feet deep and ten feet wide. A solid bed of *red hematite* is said to have been developed ten feet thick, but a mass of dirt has washed in, completely covering it up. Occasional masses may be seen in the limestone walls, and also loose pieces lying around on the sides of the bank. A considerable amount of rich *brown hematite* ore has been taken from several small pits on the southeast side of the open cut. The ore was used in the old Bushong furnace, two and one-half miles distant, and the mining of the *red hematite* is said to have been abandoned on account of the difficulty of smelting it in a small cold-blast charcoal furnace. The ore is very fine-grained, with a steel-blue color on fresh fracture, similar to the Sharp bank, and resembling very much some of the Pilot Knob (Missouri) ore. A sample, thirty-seven pieces, of the *red hematite* alone yields:

Metallic iron,	65.050
Phosphorus,	.021
Silicious matter,	2.390
Phosphorus in 100 parts iron,	.032

The *Crockett bank* lies about nine miles S. S. E. of Bristol and seven miles from Bushong Switch. It was first opened seventy-five years ago to supply ore for local forges and furnaces. The development consists of an open cut one hundred and fifty feet long, eighty feet wide and seventy-five feet deep at deepest point. At the south end of the bank a shaft, now fallen shut, is said to have been sunk thirty feet in ore-bearing clays in the present floor of the open cut, making the ascertained depth of ore material at least one hundred and five feet. The bank has yielded an excellent quality of brown hematite, with wash ore predominating. Limestone rock shows quite conspicuously on one edge of the deposit, and in this may be seen occasional wedges or lenticular masses of a rich *red hematite*. An abundant outcrop of the same character of ore covers an area of at least a hundred yards square, extending over to

the adjoining *Offield property*. The ore occurs generally in small, smooth-polished pieces, often rounded. On the outside the color is almost black, and it is known locally as "black ore." On fresh fracture it shows a dense structure, with more or less of a steel-blue color. This variety was considered too refractory to be smelted in a small cold-blast charcoal furnace, and its development has been practically ignored. It occurs in a loose, granular red clay; but it yet remains to be proven whether a solid body of ore exists at this point.

A small but never-failing stream, one hundred and fifty yards from the cut, affords an ample supply of water for washing purposes. A sample, one hundred and one pieces of the *red hematite*, shows it to contain:

Protoxide of iron,	1.928
Sesquioxide of iron,	90.214
Sesquioxide of manganese,	None.
Alumina,	1.863
Lime,	.500
Magnesia,	.317
Sulphuric acid,	.020
Phosphoric acid,	.050
Carbonic acid,	None.
Water and carbonaceous matter,	1.834
Silicious matter,	2.975
	99.701
Metallic iron,	64.650
Metallic manganese,	None.
Sulphur,	.008
Phosphorus,	.022
Phosphorus in 100 parts iron,	.034

A sample, one hundred and five pieces of the *brown hematite* from pile at open cut, yields:—

Metallic iron,	55.650
Sulphur,	.144
Phosphorus,	.020
Silicious matter,	5.500
Phosphorus in 100 parts iron,	.036

SECTION V.

Mines Along the Cripple Creek Extension.

The most important development of the brown hematite ores along the Norfolk and Western Railroad system, and considering their richness and character, one of the most important in the country, is the great iron ore belt which is opened up by the Cripple Creek Extension. The railroad passes for miles through rich outcrops of iron ore, with numerous mines now opened and worked to supply the small charcoal furnaces of the region.

This iron ore region is for the most part embraced in Pulaski, Wythe and Smyth counties in South-west Virginia. The ores lie on both sides of New River and Cripple Creek, and the railroad line following these streams renders the whole ore supply practically available for market.

The geographical map (Plate No. I,) appended to this report shows the position of this iron ore belt with reference to the main lines of transportation, and also to the coke supply from the Flat-Top coal field; and the complete table of distances on the map shows also the distances in detail to the market in Pennsylvania and other points.

The "Cripple Creek ores" (and under this term are included the New River ores of the Cripple Creek Extension,) must be divided into two distinct classes; 1st. The ores lying in the Lower Silurian Limestones; and 2nd. The so-called mountain ores geologically connected with the Potsdam Sandstone.

These ores differ widely in their methods of deposit, in their cost of mining, and in their character and uses. As the small charcoal furnaces of the district could most economically utilize the soft ores of the limestone formation, it follows that these latter deposits are the only ones which have hitherto been developed for working. The apparently greater deposits of mountain ore have been very little worked, but have been recently opened up to some extent for examination.

The *limestone ores* of the Cripple Creek region show as high a general character as any brown hematite ores mined

in the country. The result of numerous analyses shows an average richness in metallic iron of over 54 per cent in the ore dried at 212° F., with about one-tenth of one per cent of phosphorus. This unusually fine character is found to be very uniform through all the numerous mines and outcrops examined. It is somewhat extraordinary that not only is there this regularity in the percentage of iron, but also that the phosphorus shows a great uniformity in specimens taken widely apart; and in no case has it been found to exceed two-tenths of one per cent. While but few of these ores could *per se* be used to manufacture Bessemer pig-iron yet they are all of exceptionally high grade for the manufacture of any other kind of iron. They have already been well tested in the manufacture of thousands of tons of charcoal pig-iron in the region, and this iron has had a high repute in the market for car-wheel and other purposes; and the analyses given in the body of this report confirm this character. The quality of the ore is such that it smelts very easily in the furnace, and it should require a minimum amount of both flux and fuel.

The *mountain ores* of the Cripple Creek region have been but little worked, owing to the greater accessibility of the limestone deposits.

Geologically these mountain ores represent the same horizon as those which have been extensively worked in numerous other places, which have so frequently afforded large quantities of good ore, and which are now furnishing the regular supplies to the Crozer furnace at Roanoke, and to the Gem furnace at Milnes.

While these ores may be considered as belonging to one general horizon, there are really two or more separate lines of ore deposits, the lower, geologically, being always more cold-short than the upper. As a result, they cannot be expected to show the same uniformity of character as those of the limestone belt. Their general average character may be judged by the analyses of specimens taken from the long line of similar deposits along the western slope of the Blue Ridge in the Shenandoah valley, which have already been given in Section I of this report. While some of the ores

will be found to be quite cold-short, yet the average quality is such that they are well suited for the manufacture of a first class grade of foundry or forge iron.

The *quantity* of iron ore in the Cripple Creek region is undoubtedly very great. The *limestone deposits* occur in clefts and cavities of the limestone mixed with clay, but in this district rarely with any flint. The method of occurrence is such that the banks will yield widely varying quantities of ore. Some of them have been worked for many years; and shafts are reported to have been sunk 100 feet in ore-bearing clays with bottom of shaft still in ore. Frequently the ore-bearing material is of unusual richness, yielding in the washer fully one-half clean ore.

The developed mines represent but a part of the limestone ore deposits, as there are numerous rich and widely extended outcrops of iron ore which have either as yet never been tested, or else only a few shallow pits have been sunk just sufficient to show that the ore continues below the surface, without determining its depth.

These ores can be easily developed; and the building of the Cripple Creek Extension, affording them an outside market, will speedily bring about the development necessary to place technically in sight many times the amount of ore now showing.

The *mountain ore horizon* follows the foot hills of the Poplar Camp and Iron mountains, (the continuation southwest of the Blue Ridge range,) and is usually from a mile to a mile and a half back from the limestone belt. While this ore horizon will not yield a continuous ore deposit, yet wherever it is found greater or less quantities of ore may be confidently looked for. As has already been stated, these ores have not been opened in many places in the Cripple Creek region, but in one case where it has been fairly laid bare the quantity of ore exposed is enormous, and gives every evidence of making a great producing mine or mines. Indeed it seems probable that in the total amount of ore produced by this region the *mountain ores* will yield fully one-half. In the past they have played but an insignificant

part in the iron industries of the district, but in all estimates of the future they must be considered an important factor.

Sufficient has already been said to indicate both the *quality* and *quantity* of the iron ores. Neither of these will suffice to produce shipments unless there be facilities for economical mining. These facilities the region possesses in a marked degree: for the limestone ores are very free from flint, and are generally found in a loose granular clay which is easily washed out; there is abundance of water for washing purposes both in the branch streams and in Cripple Creek itself; the ore deposits are geographically and topographically well situated for mining, and the ore-bearing material is frequently of unusual richness. As a result of all these favorable circumstances, the region is to-day producing very cheap limestone ore; and the amount of such cheap limestone ore can be quickly and largely increased. It is safe to say that the district can compare favorably in the cost of production with any other brown hematite iron ore producing region.

While the high character of these ores will undoubtedly enable them to be shipped to a distance, yet the natural market for them seems to be in their own vicinity, where large coke furnaces will undoubtedly be built in the near future. The district possesses all the natural advantages for iron making—cheap and good coke from the Flat Top coal region, cheap and good ore, and a cost for flux and labor as low as any other locality.

Inasmuch as the growth of an iron-making region is necessarily slow, there will be for years extensive shipments of these ores to other markets; and as soon as the Flat Top Extension of the New River Division shall have reached the Ohio river, there will undoubtedly be an immediate demand for Cripple Creek and New River ores to supply the blast furnaces of the Ohio valley. But whether the ores be shipped or furnaces be built to smelt them in the region, the Railroad Company is certain to derive great benefit from the quantity of freight thus brought to them.

Already, even without railroad communication, the Cripple Creek region is partially developed, the business there

bearing the burden of long hauling, necessarily showing economical manufacture and a high grade of product.

The following is a list of the present charcoal blast furnaces of the district.

On South Side of New River.

Radford furnace, located on Mack's creek, Pulaski county; stone stack 35′×10′, two tuyeres, water balanced hoist and hot blast stove, steam power operating iron blowing cylinders.

Reed Island (also known as *Tipton* or *Boom*) furnace, on Little Reed Island creek, Pulaski county; stone stack 33′×9′, two tuyeres, cold blast, water power.

Barren Springs furnace, Wythe county; stone stack 35′×8′, two tuyeres, cold blast, steam power; located on the river bank.

Foster's Falls (also known as *New River* or *Pierce*) furnace, Wythe county; stone stack 36′×10′, two tuyeres, cold blast, water power; located on the river bank.

On North Side of New River.

Cedar Run furnace, Wythe county; stone stack 32′×9′, one tuyere, cold blast, water power; located on Cedar run.

Walton Furnace, Wythe county; stone stack 33′×8′, two tuyeres, cold blast, steam power.

Ivanhoe furnace, Wythe county; brick banded stack on columns, 42′×11′, six tuyeres, hot blast stove, and steam blowing engine; located near the river bank.

On Cripple Creek.

Brown Hill furnace, Wythe county; stone stack 40′×8½′, two tuyeres, cold blast, steam power.

Raven Cliff furnace, Wythe county; stone stack 29′×9′, three tuyeres, cold blast, water power.

Irondale (or Noble) furnace, Wythe county; stone stack 33′×9′, two tuyeres, cold blast, steam power.

Eagle furnace, Wythe county; stone stack 34′×9′, one tuyere, cold blast, water power.

Beverly furnace, Wythe county; stone and brick stack 33′×9′, three tuyeres, cold blast water power.

Cave Hill furnace, Wythe county; stone stack 47′×10′, two tuyeres, cold blast, steam blowing engine.

Wythe furnace, Wythe county; stone stack 33′×9′, one tuyere, cold blast, water power.

Speedwell furnace, Wythe county; stone stack 32′×9′, one tuyere, cold blast, water power.

White Rock furnace, Wythe county: stone stack 38′×9½′, two tuyeres, cold blast, steam power.

Description of ore properties along the Cripple Creek Extension.

The detailed description which is given below begins at the eastern end and follows regularly westward.

Pulaski County.

Radford furnace is situated on Mack's Creek, one and one eighth miles from its junction with New River. The stack is 35×10 feet, producing charcoal pig-iron for car wheels. Iron ores have been opened up at several points in the slates underlying the limestones, in the immediate vicinity of the furnace. About one hundred yards east of it a face of ore-bearing clays is exposed 40×15 feet, showing some fairly rich ore—sometimes impregnated with manganese.

Five hundred feet west of the furnace, a tunnel has been run in a north-east and south-west direction for a distance of three hundred feet, with ore all the way along and end of tunnel still in ore. Mining operations were conducted by means of side drifts averaging fifteen feet long. The ore is said to have been nearly all lump ore of good quality.

Three quarters of a mile W. S. W. from the furnace, the same deposit has again been developed by an irregular-shaped open cut. This is known as the "*Nuegan diggings.*" The ore shows quite conspicuously in the faces of the cut, the proportion of lump being about one half. Sam-

ples, one hundred and eighty pieces, were selected from all over the cut. They yield on analysis:

Metallic iron,	46.425
Phosphorus,	.963
Silicious matter,	17.090
Phosphorus in 100 parts iron,	2.074

Four miles east from Radford furnace, on *'Squire J. G. Cecil's property*, a bold outcrop of ore is exposed on the east face of a ridge on Mack's mountain. The outcrop, or float, covers a seemingly well-defined area of one hundred and forty by sixty feet, very little ore being seen outside of this limit. Much of it is a rich, dark brown hematite, while, on the other hand, large lumps of quite pure manganese ore are found. No work has been done to test the extent of the deposit, but the outcropping ore is in large masses and quite abundant. Samples, one hundred and thirty-two pieces, were selected to represent its average character. They yield:

Metallic iron,	39.975
Metallic manganese,	14.785
Phosphorus,	1.074
Silicious matter,	5.840

Clark bank is situated on the north side of New river, about one and one-half miles from the mouth of Big Reed Island Creek. This bank is now operated by the Radford Iron Company, and furnishes most of the stock at present used at their furnace on Mack's Creek. The bank is five miles west from Radford furnace, and is worked by open cut, showing occasional boulders of limestone. A shaft is said to have been sunk sixty feet in ore. An area of five or six acres has been proven as ore territory. A sample, one hundred and eighty-five pieces from ore pile at Radford furnace, yields:

Metallic iron,	55.925
Phosphorus,	.128
Silicious matter,	3.600
Phosphorus in 100 parts iron,	.228

The Rich Hill or Forney property is situated near New

River at the confluence of the Big and Little Reed Island Creeks, the ore developments being on an elevated ridge overlooking New River.

Ore territory has been proven by test pits over a considerable area, but only a small quantity of the ore has as yet been mined, for local use in a forge The pits and small open cuts vary in depth from a few feet to thirty-four feet, and in many of them the ore shows practically to the surface. It is generally an open, cellular brown hematite of excellent quality—the present development showing a large proportion of lump ore. Ore has been found in all of the shafts, and the indications are favorable for a large body of it. Samples, one hundred and seventy-six pieces, were selected from nine different openings, extending over a large area. An analysis shows the ore to have the following composition:

Bisulphide of iron,	None.
Protoxide of iron,	None.
Sesquioxide of iron,	76.214
Sesquioxide of manganese,	.051
Oxides of nickel and cobalt,	.040
Oxide of zinc,	None.
Oxide of lead,	None.
Oxide of copper,	None.
Alumina,	2.365
Baryta,	None.
Lime,	.820
Magnesia,	.486
Sulphuric acid,	.157
Phosphoric acid,	.171
Water,	12.072
Silicious matter,	7.480
	99.856
Metallic iron,	53.350
Metallic manganese,	.036
Sulphur,	.063
Phosphorus,	.075
Phosphorus in 100 parts iron,	.140

Wythe County.

The "*Johnson ore bank*" on the property of the Reed Island Iron Company on Little Reed Island, one and one

fourth miles from New River, is situated on a high bluff three hundred yards north of the Reed Island ("Boom") furnace. The bank exhibits a series of openings or irregular-shaped cuts, the deepest workings being about fifty feet. The ore crops to the surface at some points, while at others it is covered by eight to ten feet of over-burden consisting of loose gravel and clay. Noses and ledges of limestone occur frequently in the mine; but large masses of rich ore are found between the limestone ledges. On the west face the ore is mined from the surface down. Thirty yards east of the first opening, the ore is covered by an average of eight feet of stripping. Here the present face shows twelve to fifteen feet of ore material; and a natural shaft at the edge of a limestone boulder shows ore for an additional twenty feet. Although considerable limestone shows in the bottom of the cut, yet this feature is not so pronounced as on the west side of the deposit. Ore territory has been proven by shafts in an E. N. E. direction for one thousand yards, and in a north-west and south-east direction for seven hundred and fifty yards. The average over-burden is about five feet. Ore material yields from a third to a half clean ore. A washer is situated on Little Reed Island Creek just below the bank, and ore material is conveyed there by means of a chute.

The "King Bank" is situated on the opposite side of the ravine, and is practically a continuation in a south-west direction of the Johnson bank. It is opened along the face of a hill for a distance of about three hundred yards, with an average of eight to ten feet of stripping. A shaft has been sunk thirty-two feet in ore; and at another point forty feet of ore has been developed. The same general features prevail here as at the Johnson bank and the ore is of a similar character. One washer is used for both banks, and the ore in each case is conveyed to it by means of a chute. Little Reed Island Creek furnishes an abundant supply of water for washing purposes at all seasons. A sample, about twenty pounds taken from ore pile at washer, yields:

Metallic iron,	55.300
Phosphorus,	.085
Silicious matter,	7.270
Phosphorus in 100 parts iron,	.153

On this property ("Boom" furnace,) near Big Reed Island Creek and 1½ miles south-east from Forney's, there is a conspicuous outcrop of the *mountain ore.* It shows plainly on the two sides of a steep ravine. The outcrop ore is much mixed with pieces of ferruginous sandstone; and no work has been done to determine the character and quantity of ore underlying the surface shows. Samples, 98 pieces of the *good ore*, were taken to show the relationship of the iron to the phosphorus. They yield on analysis:

Metallic iron,	51.800
Phosphorus,	.275
Silicious matter,	7.680
Phosphorus in 100 parts iron,	.530

Cedar Run Furnace.

The ore bank which supplies this furnace is known either as the "*Graham*" or "*Carter*" bank. It is situated one and one fourth miles S. E. from the furnace and about three quarters of a mile W. N. W. from New River. The bank exhibits a series of openings from which a large amount of ore has been mined. The present workings consist of a circular pit eighty feet in diameter and fifteen to eighteen feet deep, with ore in bottom not gone through. No limestone has been observed at this point.

Thirty yards further south it is worked on a lower level to a depth of fifty feet; and a shaft sunk on the floor of this cut has gone through ore to an additional depth of seventy-five feet, making at least one hundred and twenty-five feet of ore material at this point.

Forty yards south-east from the present workings, one shaft has been sunk in ore for one hundred and two feet; and a second has gone down eighty feet in ore, with bottom of shaft still in ore. Numerous other cuts and shafts have been made, but these are now fallen shut. The bank has

been worked in such a way that it presents the appearance of a series of benches or terraces on the face of a hill. Ore crops to surface generally, although sometimes as much as six feet of stripping has to be removed. Occasional horse-backs of clay carrying little or no ore have been encountered; but neither these nor limestone boulders have been very pronounced in any of the workings. An area of four to five acres has been proven by shafts to be ore territory. Every indication points to a large body of ore—principally wash ore.

At present the ore is hauled to Cedar Creek, which furnishes a constant water supply for washing. Both New River and Cedar Creek can be reached by easy down grades, so that an abundant supply of water can be depended upon at all seasons. Ore material washes one half clean ore. A sample, about twenty pounds selected from ore pile at furnace, yields:

Metallic iron,	54.400
Phosphorus,	.137
Silicious matter,	7.870
Phosphorus in 100 parts iron,	.251

A sample of the pig-iron made in the Cedar Run furnace shows the following:

Silicon,	.547
Sulphur,	.052
Phosphorus,	.205

Pierce furnace is situated on New River, and its ore bank lies one mile south-east from the furnace. The present workings consist of a long narrow cut, three hundred feet long and about twenty feet at deepest point, with six feet overburden. The ore occurs in the limestone along the strike of the rocks, which is here nearly north-east and south-west. But few boulders of limestone have been encountered in any of the workings. Near the mouth of the drift an occasional horse-back of sand or clay may be noticed; these, however, are of little importance. The ore face shows some rich-looking dark-brown laminated lump ore, with

occasional streaks of iron pyrites; but the greater part is wash ore material, yielding one-half to two-thirds clean ore.

Half a mile south-east from the furnace, a tunnel has been run in almost due south for about twenty feet in ore. W. S. W. of this, a second tunnel has gone through fifteen feet of ore, without any solid limestone being encountered in either case. Here the overburden is from three to four feet, and the floor of the above-mentioned tunnels is ten feet below this.

A quarter of a mile south-east from the furnace, a drift about two hundred and fifty feet long, twelve feet wide and thirty feet at deepest point, shows ore all the way along between ledges of limestone. Other developments from which a good deal of ore has been mined show the same general features.

About four hundred acres of this property are said to have been proven as ore territory.

The ore material is carried by tramway to the washer at New River. The washer is a single shaft, fifteen feet long, with a capacity of fifteen to twenty tons of clean ore daily.

A sample, about twenty pounds, representing the *wash ore* was selected from ore pile at washer. It yields:

Metallic iron,	57.200
Phosphorus,	.074
Silicious matter,	5.300
Phosphorus in 100 parts iron,	.129

On the same property, about one and a half miles south-east from the furnace, there is a large outcrop of *mountain ore* extending along the foot-hills for a considerable distance. A mile further along, the same character of ore is said to be found outcropping in large boulders nearly fifty feet thick. This represents the ore occurring in the ferriferous slates underneath the limestone, and found in the foot-hills along the western slope of the Blue Ridge the whole length of the valley. Some ore has been mined from this horizon for use in the furnace, and the openings were known as the "*Hammer bank.*" A sample, seven hundred

and eighty pieces selected by Wesley Shockley, Superintendent of the ore mines, yields the following analysis:

Protoxide of iron,	.161
Sesquioxide of iron,	77.071
Sesquioxide of manganese,	.020
Sesquioxide of cobalt,	.020
Oxide of zinc,	.020
Alumina,	2.250
Lime,	.460
Magnesia,	.497
Sulphuric acid,	.300
Phosphoric acid,	.455
Water,	11.514
Silicious matter,	7.175
	99.943
Metallic iron,	54.075
Metallic manganese,	.014
Sulphur,	.120
Phosphorus,	.199
Phosphorus in 100 parts iron,	.368

A sample of the *charcoal pig-iron* made at the Pierce furnace shows the following partial analysis:-

Silicon,	.387
Sulphur,	.040
Phosphorus,	.144

Walton furnace lies three miles north-east from Cripple Creek, and two and one half miles north from New River. The bank from which this furnace draws its principal supply of ore is known as the "*Sanders ore bank.*" It is situated three fourths of a mile north-east from the furnace. It has been worked by open cut probably one thousand feet long, thirty to forty feet wide and twenty-five feet deep at deepest point. For about an average of five feet from the surface down the ore occurs as a thick wash in a loose clay, but below this the clay is tough and comparatively lean, yielding not more than one fourth clean ore. At the N. N. W. end of the cut the top-covering of rich ore material is very thin.

Several other openings which have been made show practically the same condition as stated above. An abun-

dant outcrop of rich wash ore covers a considerable area near the present workings.

The ore material is conveyed by tramway to a small stream near the furnace to be washed. The supply of water, although permanent, becomes quite low during the summer months. A sample of the ore, two hundred and sixty-three pieces from pile at furnace, shows the following:

Metallic iron,	51.625
Phosphorus,	.111
Silicious matter,	10.730
Phosphorus in 100 parts iron,	.215

Three miles north of Walton furnace is the "*Glade Manganiferous ore bank*," worked by shaft and tunnel. The character of the ore seems to vary somewhat, being sometimes a rich brown hematite—often fibrous and quite free from manganese; while on the other hand, portions of it are highly charged with manganese—this element not unfrequently predominating. The ore is simply screened, there being no water for washing purposes in the vicinity of the mine. About one-twelfth of the burden of the Walton furnace at present consists of this ore. A sample, one hundred and forty-three pieces selected from small ore pile at furnace, yields:

Metallic iron,	50.450
Metallic manganese,	4.971
Phosphorus,	.444
Silicious matter,	5.440

Brown Hill furnace is situated on the west bank of Cripple Creek, and the furnace property adjoins that of the New River Mineral Company, next to be described.

Painter ore bank, three miles south-east from the furnace is now being worked for a supply of ore; but as yet it has been but little developed. A sample of the ore, three hundred and twenty-five pieces selected from pile at Brown Hill furnace, yields the following analysis:

Metallic iron,	49.350
Phosphorus,	.109
Silicious matter,	13.930
Phosphorus in 100 parts iron,	.220

Ivanhoe Furnace.

New River Mineral Company's property. (*Van Liew's.*)

This property is situated on New River, eleven miles S. S. E. from Max Meadows. The furnace has been but recently built, and has all the modern improvements, with warm-blast attachment. The stack is 42X11 feet; six tuyeres with three and a half inch nozzle; upright blowing engine with forty-eight-inch blowing cylinder and two-foot stroke. Capacity, twenty to twenty-five tons per day of cold-blast charcoal car-wheel iron.

The ore bank is located a quarter of a mile from the furnace. Ore crops to the surface over a considerable area. The present working face is one hundred and fifty feet long and twenty-five feet deep. Occasional noses or ledges of limestone come in and cut out the ore, but at present these are insignificant. The ore material washes one-third to one-half clean ore. So far as the ore territory has been proven —some ten acres—about an average of one-third is lump ore, but at some points practically the whole of the ore is lump.

In addition to the workings above mentioned, tunnels have been driven in an east and west direction for one hundred and fifty feet, and in a north and south direction for a distance of three hundred feet. But few limestone boulders were encountered in these drifts. At deepest point the tunnel is forty-five to fifty feet from surface.

Ore was taken out from these tunnels until it was deemed cheaper to open out the bank to day-light on the tunnel level; and since that time much cheap ore has been taken from this open work. As is usual in limestone deposits, there is a greater proportion of solid limestone to the ore-bearing mass on the lower level than was found above. The ore bank is now yielding a full supply of ore for the use of the furnace at a very low cost, and the prospects are favorable for their continuing to receive such supply for a long period.

Ore is said to have been proven to a depth of one hundred feet; but average developments are not over twenty-five feet. In the deeper workings occasional masses of iron py-

rites are encountered; and at some points on the property there are good indications for both zinc and lead.

At present there are two single shaft washers—one at the furnace and one at the ore bank. That at the furnace is twenty-two feet long, and has a daily capacity of twenty-five tons. The one at the ore bank—now being used—is thirty-two feet long, and has a daily capacity of thirty-five to forty tons of clean ore. A small stream flowing alongside of the ore deposit furnishes water for washing, but in dry seasons it does not yield a sufficient supply. A well sunk near the washer to a depth of twenty-five feet struck a strong supply of water, sufficient for all present purposes.

The lump ore is generally roasted before being used; but the stock supplied to the furnace is nearly all wash ore. Separate analyses were made of each.

Lump ore. A sample, two hundred and fifteen pieces, was selected from small ore piles at the different openings. It yields the following analysis:

Bisulphide of iron,	.064
Protoxide of iron,	.047
Sesquioxide of iron,	80.618
Sesquioxide of manganese,	.103
Oxides of nickel and cobalt,	.060
Oxide of zinc,	.150
Oxide of lead,	.184
Oxide of copper,	Trace.
Alumina,	1.476
Baryta,	None.
Lime,	.750
Magnesia,	.515
Sulphuric acid,	.092
Phosphoric acid,	.110
Water,	11.174
Silicious matter,	4.500
	99.843
Metallic iron,	56.500
Metallic manganese,	.072
Sulphur,	.071
Phosphorus,	.048
Phosphorus in 100 parts iron,	.085

A sample of the *wash ore*, consisting of fifteen pounds, was selected from different parts of the ore pile at washer. It yields:

Metallic iron,	51.600
Phosphorus,	.068
Silicious matter,	8.810
Phosphorus in 100 parts iron,	.131

Two samples of the *pig-iron* made at different dates were analyzed with the following results:

Silicon,	2.640
Sulphur,	.040
Phosphorus,	.124

A second sample, made two months later, shows the following:

Carbon, combined,	.783
Carbon, graphitic,	2.950
Silicon,	2.074
Sulphur,	.020
Phosphorus,	.166
Manganese,	.194
Iron, (by difference,)	93.863
	100.000

Chadwell Property.

At a point about four hundred yards south-east from Cripple Creek, iron ore has been developed to some extent on this property along Porter's road, and a small quantity of it mined for use in the blast furnace. On the east side of the road an abundant outcrop of brown hematite covers a large area in a north-east and south-west direction. Sometimes it shows a rich and pure brown hematite, while on the other hand it is often full of drusy cavities lined with quartz crystals; and occasionally it is highly manganiferous. But this condition may be merely confined to the surface, as the ore mined from deep workings along Porter's road is quite free from impurity, as shown by the following analysis of a sample, one hundred and thirty-eight pieces, of the wash ore obtained at this point:

Metallic iron,	56.500
Phosphorus,	.145
Silicious matter,	4.570
Phosphorus in 100 parts iron,	.256

The Sansom property adjoins the Chadwell on the west side. No systematic development of its iron ore has yet been made. Several small shafts and open cuts or trenches have been put down, but these are now fallen shut. One shaft is said to have struck ore material at six feet, and to have gone down on it forty feet. At several points quite an abundant outcrop may be seen, exhibiting the same variation in character of the ore as on the Chadwell property last described.

From an outcrop in a ravine ½ mile N. E. of Sansom's house a sample, 183 pieces, was taken for analysis. It yields:

Metallic iron,	52.275
Phosphorus,	.113
Silicious matter,	8.020
Phosphorus in 100 parts iron,	.216

A qualitative test shows the presence of manganese in quite appreciable quantity; but it has not been thought necessary to determine the percentage.

On the *Wythe Lead and Zinc Mining Company's property*, near Austinville, there is quite an abundant outcrop of a rich-looking brown hematite ore, extending over a large area; but no developments have been made to test the extent of the deposit. Samples, one hundred and fifteen pieces, were selected for analysis from loose surface ore. They show:

Metallic iron,	53.925
Phosphorus,	.105
Silicious matter,	5.400
Phosphorus in 100 parts iron,	.194

On this Company's property, about two miles from Ivanhoe furnace, an abundant float of brown hematite *mountain ore* occurs at the foot of Poplar Camp mountain, covering a considerable area. No development of the ore has yet been made. Samples, consisting of one hundred and twenty-five pieces from loose surface ore, yielded the following analysis:

Metallic iron,	49.550
Phosphorus,	.179
Silicious matter,	13.710
Phosphorus in 100 parts iron,	.361

Eagle furnace obtains a large supply of its stock from the "*Old Field ore bank*" situated about one quarter of a mile south-east of the furnace. The bank is worked by open cut, the ore material yielding about one half clean ore—nearly all fine wash ore. A sample, twenty-five pounds from ore pile at the furnace, yields:

Protoxide of iron,	None.
Sesquioxide of iron,	81.142
Sesquioxide of manganese,	.268
Sesquioxide of cobalt,	.060
Oxide of zinc,	.020
Alumina,	1.510
Lime,	.370
Magnesia,	.720
Sulphuric acid,	.065
Phosphoric acid,	.293
Water,	11.014
Silicious matter,	4.835
	100.297
Metallic iron,	56.800
Metallic manganese,	.187
Sulphur,	.026
Phosphorus,	.128
Phosphorus in 100 parts iron,	.225

Locust Grove farm bank, on the property of Captain W. O. Moore, is situated about half a mile north from Cripple Creek and two miles from Eagle furnace. No systematic development of the ores has yet been made on this property. An abundant outcrop of rich brown hematite extends in an east and west direction for over a mile, and it has a width—north and south—of about three hundred feet. The ore occurs in the limestone, occasional noses and ledges of which may be seen; but in the main the line of the ore deposit seems quite free from outcropping rock. On the northern edge of the deposit, a shaft is said to have been sunk to a depth of twenty feet, showing ore from surface down. Huddle Branch, a small but permanent stream flows along the edge of the deposit to Cripple Creek; and Cripple Creek itself can be reached by easy grade, with an abundance of water for washing purposes. A sample, one hundred and thirty pieces, selected from surface ore over a considerable area, shows the following:

Metallic iron,	56.775
Phosphorus,	.092
Silicious matter,	4.330
Phosphorus in 100 parts iron,	.162

Noble Furnace Property. (*Norma Iron Company.*)

The Noble furnace draws its chief supply of ores from banks which are opened up in the immediate vicinity and connected with the furnace by tramway. They lie near a good never-failing stream which affords an abundance of water for washing.

The *mountain ores* are opened in several places, partly for furnace use but chiefly for showing the great amount of ore on the property which can be economically mined.

"*No. 1 opening*" consists of a cut about twenty-five feet deep, with ore showing quite prominently in the faces. At some points the ore is quite *manganiferous*; but this variety could be mined separately if desired. A sample, one hundred and twenty-seven pieces selected from all over the cut, will fairly represent the average. It yields on analysis:—

Bisulphide of iron,	.017
Protoxide of iron,	None.
Sesquioxide of iron,	70.060
Sesquioxide of manganese,	4.531
Oxides of cobalt and nickel,	.110
Oxide of zinc,	.090
Oxide of lead,	None.
Oxide of copper,	None.
Alumina,	2.070
Baryta,	.230
Lime,	.670
Magnesia,	.515
Sulphuric acid,	.080
Phosphoric acid,	.409
Water,	10.306
Silicious matter,	10.770
	99.858

Metallic iron,	49.050
Metallic manganese,	3.155
Sulphur,	.041
Phosphorus,	.179
Phosphorus in 100 parts iron,	.365

"*No. 2 opening*," or the "*Outburst*" opening, as it is locally called, lies on the slope and crest of one of the low foot hills of Iron Mountain. The outcrop is so great as to almost cover the surface of the ground from the crest to the foot of the hill-slope, a distance of several hundred feet. A cut has recently been made into the ore-bearing mass at the foot of the slope, and from this point the ore is traced in a continuous outcrop to the "outburst" on the crest, where a great mass of solid ore is laid bare for examination. Samples, 170 pieces representing the iron ore of the whole hill-slope from the base to the outburst, yield the following results on analysis:

Metallic iron,	50.750
Phosphorus,	.168
Silicious matter,	8.560
Phosphorus in 100 parts iron,	.331
Combined water,	13.080

From the solid ore of the "*outburst*" itself samples, 143 pieces, were taken for analysis. They yield:

Metallic iron,	51.550
Phosphorus,	.126
Silicious matter,	7.760
Phosphorus in 100 parts iron,	.244

"*No. 3 opening.*" Along the continuous outcrop of the outburst ore, and only 500 feet away from the outburst opening there is a very heavy surface ore-show, and a trench has been cut across the crop showing rich ore-bearing stuff for a distance of 106 feet, with much lump ore, and in places ore masses as solid as at the outburst opening. Samples were taken (150 pieces) representing the wash and lump ore exposed on the whole length of the cut, which analyzed as follows:

Metallic iron,	50.075
Phosphorus,	.325
Silicious matter,	14.020
Phosphorus in 100 parts iron,	.649
Combined water,	10.460

"*No. 4 opening.*" About 150 yards south of the Outburst opening No. 1, and on what is known locally as the "back vein," there is a small trial opening on a marked surface outcrop of ore. A sample, 50 pieces, shows the following:

Metallic iron,	49.725
Phosphorus,	1.388
Silicious matter,	7.880
Phosphorus in 100 parts iron,	2.791

"*No. 5 opening.*" On Hussey mountain there is a second opening on this "back vein" which shows much solid ore in the face of the cut. A sample, 165 pieces, taken from ore pile lying in front of opening yields:

Metallic iron,	52.225
Phosphorus,	1.228
Silicious matter,	6.560
Phosphorus in 100 parts iron,	2.351

Both of these ores from the "back vein" show quite an appreciable amount of manganese, but it has not been considered desirable, under the circumstances, to determine its percentage.

The *limestone ore* has yielded the greater part of the stock which has been used in the Noble furnace. It is opened and worked on both sides of Francis Mill Creek. The workings on the east side consist of several small and shallow pits. A sample of this ore, about 15 to 20 pounds, was taken from the ore pile at washer. It yielded:

Metallic iron,	55.400
Phosphorus,	.127
Silicious matter,	7.960
Phosphorus in 100 parts iron,	.229

On the west side of Francis Mill Creek, the ore has been extensively worked in what is called the "*Porter bank.*" It is situated on the north slope of Hussey mountain, about 1¼ miles W. N. W. from the Noble furnace,

and is worked by open cut showing a breast of ore material 50 feet wide and 40 feet deep at the deepest point. On the south side of the cut and about 20 feet from it, a shaft is said to have been sunk in ore 70 feet, with bottom of shaft still in ore; and ore territory has been proven by test pits in a W. S. W. and E. N. E. direction for a third of a mile or more. The average stripping is about 6 feet, consisting chiefly of loose soil with occasional masses of sandstone.

The deposit lies about ¾ mile from Cripple Creek, where the ore can reach the railroad (Cripple Creek Extension) by easy down grades. The ore is at present hauled over a tramway to the washer on Francis Mill Creek. It washes about one half clean ore—principally fine shot ore, with perhaps ten per cent lump ore. A sample (15 to 20 pounds) selected from ore pile at washer, yields the following results on analysis:

Metallic iron,	57.200
Phosphorus,	.111
Silicious matter,	4.730
Phosphorus in 100 parts iron,	.194

Speedwell furnace is situated on Cripple Creek, and the ore bank which supplies it lies one and one half miles south from it. The bank is worked by an open face two hundred and fifty feet long and twelve feet deep. The ore crops to the surface, and the bottom of the cut is still in ore-bearing clay. The ore material, which is washed at Cripple Creek, yields about one half clean ore, nearly all fine. At present the daily output is twelve tons of clean ore.

An abandoned open cut, about two hundred feet in diameter and sixty-five feet deep, lies a short distance southeast from the present operations. Here the overburden is about eight feet.

An abundant outcrop of wash ore extends in a N. N. E. direction for several hundred yards, indicating a large deposit at this point. A sample, three hundred and ten pieces from ore pile at washer, yields the following analysis:

Protoxide of iron,	None.
Sesquioxide of iron,	78.107
Sesquioxide of manganese,	1.884
Sesquioxide of cobalt,	.110
Oxide of zinc,	.220
Alumina,	1.410
Lime,	.710
Magnesia,	.677
Sulphuric acid,	.012
Phosphoric acid,	.451
Water,	10.576
Silicious matter,	11.510
	100.117
Metallic iron,	51.175
Metallic manganese,	.929
Sulphur,	.005
Phosphorus,	.197
Phosphorus in 100 parts iron,	.384

White Rock Furnace.

Crigger bank at present furnishes the chief supply of ore for the White Rock furnace. The bank is situated about one eighth mile from the middle branch of Cripple Creek, and two miles south-east from the furnace. It consists of an open cut 40×25×12 feet, and has been operated but a few months. The ore material is hauled over a tramway to washer. Water for washing purposes is obtained from a branch of Cripple Creek which yields a permanent supply at all seasons. Ore material washes one third to one half clean ore, the washer producing fifteen to twenty tons daily. The bank averages about one sixth lump ore.

At a point some five hundred yards east of the present workings considerable ore has been mined, but the deposit seemed to have no great depth. A sample, three hundred and twenty-five pieces from the *new bank*, selected from pile at White Rock furnace yields:

Metallic iron,	53.725
Phosphorus,	.064
Silicious matter,	7.770
Phosphorus in 100 parts iron,	.119

Smyth County.

On the property of Mr. A. J. Williams, the "*Razor bank*" has been opened up on the *mountain ore* near the south fork of the Holston river in Rye valley. But little development has been made. A shaft is said to have been sunk twelve feet deep, and to have yielded a good deal of ore. A tolerably rich outcrop covers a considerable area along the flank of Chestnut ridge. At some points the ore shows considerable manganese. A sample, one hundred and thirty-three pieces from a small pile lying at shaft and from loose outcropping ore, yields:

Metallic iron,	40.100
Metallic manganese,	10.181
Phosphorus,	.536
Silicious matter,	10.520

On the north face of Cow Ridge, near its base, *Alexander, Neitch & Roland* have opened up a bed of *red hematite* (specular ore) about two miles from the south fork of the Holston river, and some six miles S. S. E. from Seven Mile Ford station, N. & W. R. R. The developments consist of four small shallow open cuts, covering a length of about one hundred yards along the bed; and the deposit is said to have been traced for a considerable distance beyond this. But a sufficient amount of work has not yet been done to thoroughly test the extent and value of the deposit. Since the date of my visit, Mr. Alexander writes that he has opened up the ore to a depth of 10′ 5″, and found it very heavy and of much better quality than when I saw it. The opening is near Jerry's Creek. Samples, one hundred and fifty-seven pieces, were selected from the different openings. They yield on analysis:

Metallic iron,	56.800
Phosphorus,	.075
Silica,	12.770
Phosphorus in 100 parts iron,	.132

On the same land, on what is locally known as Chestnut Ridge, several openings have been made showing a rich quality of manganese ore. No solid body of it, however,

has yet been developed; but from the few cuts already made some fifteen or twenty tons of a rich-looking ore have been dug, and the indications are sufficient to justify further explorations.

SECTION VI.

Miscellaneous Iron Ores in Montgomery, Craig and Bland Counties.

Under this heading are given the analyses of ores from isolated banks outside of the districts covered by this report. The first four are of specimens collected by W. W. Coe, Esq., Chief Engineer of the Railroad Companies, during the course of an examination of the Blacksburg district, Montgomery county.

No. 1. From the lands of *Mr. Giles J. Henderson*, near Blacksburg, on the slope of Brush mountain facing southeast. Small excavation made in 1862, and ore hauled to furnace on Craig's Creek. Sample, ninety pieces.

No. 2. *On same lands*, near David Martin's house. Surface specimens in ravine east from No 1. Surface indications extend up the slope for about two hundred yards. Sample, ninety-five pieces.

No. 3. *On same lands*, directly up the hill, two hundred yards distant from No. 2, and seemingly on top of outcrop. Sample, sixty pieces.

No. 4. From the lands of *James Robinson*, deceased. Specimens were taken from the summit of a round-topped hill; and surface indications seem to cover an area of about one acre. Sample, eighty-five pieces *pipe ore*.

	No. 1.	*No. 2.*
Metallic iron,	45.450	47.850
Phosphorus,	.176	.556
Silicious matter,	21.240	16.540
Phosphorus in 100 parts iron,	.387	1.162
	No. 3.	*No. 4.*
Metallic iron,	44.150	56.450
Phosphorus,	.709	.061
Silicious matter,	22.440	6.040
Phosphorus in 100 parts iron,	1.605	.108

On Gap Mountain, about three miles south-east from the Sinking Creek furnace, the *Martin bank* has been opened by tunnel, showing a bed of argillaceous red ore averaging two feet in thickness. The main tunnel has been run in a north-west direction for about two hundred feet, striking ore at this point. Side drifts have been made on the ore in a north-east and south-west direction for a distance of one hundred and thirty feet each way. The general strike of the rocks is north-east and south-west, with an easterly dip. The ore varies from one to six feet in thickness, with an average of two feet, as already stated. The walls are sandstone and clay.

Several other tunnels show the same general features. The bank has been worked for about eight months, yielding twenty tons of ore per day, all of which is hauled to the Sinking Creek furnace near Newport. Samples, one hundred and ninety pieces, were selected from ore pile at mouth of the main tunnel, to represent the ore as mined—carrying an occasional piece of clay wall-rock=No. 1. Later samples, forty pieces, were selected by Mr. Coe, from ore in place in side drifts=No. 2.

The results of the analysis of these samples are as follows:

	No. 1.	*No. 2.*
Metallic iron,	34.750	37.850
Phosphorus,	.354	.432
Silicious matter,	33.380	28.900
Phosphorus in 100 parts iron,	1.018	1.141

Craig County.

On the Sinking Creek furnace property, about three and one fourth miles north-east from the furnace, the *Mills bank* has been worked by open cut and tunnel. The open cut is irregular in shape, several hundred feet long from mouth of drift, forty-five feet wide, and thirty-five feet deep, extreme measurements. Two tunnels have been driven in for several hundred feet, showing a body of lump ore varying in thickness from five feet to thirty feet. About ten thousand tons of ore have been taken out. The bank has

not been worked for eighteen months, and everything has so fallen shut that but little can be seen. It is located on John's Mountain, about half a mile from Sinking Creek. Samples of the ore, one hundred and ninety-five pieces from the old dumps, show:

Metallic iron,	53.350
Phosphorus,	.089
Silicious matter,	10.870
Phosphorus in 100 parts iron,	.161

Bland County.

On the lands of *Capt. Edward Peery*, on the south slope of Round Mountain, seven miles N. N. W. from Bland Court House and half a mile north from Paul James' house in Hunting Camp Valley, a bold outcrop of solid brown hematite ore is exposed; but there have been as yet practically no developments made to ascertain the extent of the deposit. The exposure measures 11′ 6″ across the face where it has been blasted off; and some twenty or thirty yards from this point a similar exhibition is made. The indications seem to point to the existence of a considerable deposit of rich ore.

A sample, one hundred and fifteen pieces taken across the entire face of exposure, yields the following analysis:

Metallic iron,	56.100
Phosphorus,	1.160
Silicious matter,	3.720
Phosphorus in 100 parts iron,	2.065

CHAPTER II.

Zinc and Lead Ores.

The mining of zinc and lead ores now forms an important industry in south-west Virginia. The ores are found in the body of the Great Limestone formation, No. II; and at some points quite extensive deposits have been opened up, but no detailed examination was made of these. In addition to

the actual working at the places described below, there is considerable prospecting for zinc and lead now being done on the south side of New River opposite Ivanhoe furnace, and also on the Barren Springs furnace property. Favorable reports are received from these prospecting enterprises.

At the *Bertha Zinc mine*, situated near New River below the mouth of Reed Island Creek, the ore occurs chiefly as silicate and carbonate of zinc. It comes practically to the surface, and it has been proven to a depth of sixty-five feet. It is dried in kilns at the mine, and then hauled to the Zinc Works at Pulaski. During 1881, two thousand five hundred tons were shipped from the mine. Preparations have been made for largely increasing this output as soon as the railroad reaches the mine. A sample of the crushed and roasted ore, selected from pile at Works at Pulaski, yields :

Metallic zinc,	**37.836**
Metallic lead,	**None.**

At the *Wythe Lead and Zinc Company's mines* at Austinville on New River, both lead and zinc have been mined for over a hundred years. Only the lead ore is reduced at the works, the zinc ore being shipped to the Zinc Works at Pulaski and to Trenton, New Jersey. The lead occurs for the most part as galena, with only an occasional occurrence of the carbonate; and the zinc as silicate, carbonate and sulphide. The ores are mined along and across the trend of the limestone rocks; and the deposit has been proven by shafts and tunnels for a length of nearly ten thousand feet. It varies considerably in thickness, being more or less lenticular in character. The greatest width developed has been one hundred and fifty feet, and the greatest depth one hundred and ninety feet, with ore still in workings. The bottom of the deposit has not yet been reached, as the mine has been worked so as to be self-draining. Samples were selected from piles at the Works to represent the different varieties of the *prepared ore*, as follows.

No. 1. Sample of *lead ore, second separation.* Crude ore yields about six per cent. similar to sample. An analysis shows:

Metallic lead,	65.836
Metallic zinc,	5.408

No. 2. *Concentrated zinc blende.* Crude ore yields five to six per cent. similar to sample. It contains:

Metallic zinc,	32.797
Metallic lead,	10.090

No. 3. *Concentrated zinc silicate and carbonate.* Crude ore yields about thirty per cent. similar to sample. An analysis shows it to contain:

Metallic zinc,	26.368
Metallic lead,	5.629

In Hog Trough Valley of Smyth county, on the east side of the Grayson turn-pike road, zinc ore has been quite recently developed by Alexander and Neitch on the property of Jackson and Martin, near the South Fork of the Holston River and eight miles south from Marion. Practically no work had been done at the date of examination; but recent developments are said by Mr. Alexander to be very satisfactory, and the deposit promises to be quite an extensive one. The ore occurs in dolomitic limestone, principally as silicate with an occasional occurrence of the sulphide. A sample selected from a face four feet wide yields:

Metallic zinc,	.802
Metallic lead,	.119

A sample selected by Mr. Alexander from more recent developments shows:

Metallic zinc,	6.780
Metallic lead,	.170

CHAPTER III.

Gypsum (*Plaster.*)

In Smyth and Washington counties of south-west Virginia large quantities of gypsum are annually mined, the principal developments being in the neighborhood of Saltville. The deposits have been examined at different times by geologists, and all agree that the quantity must be very great.

Although the discussion of this mineral does not properly come within the province of this report, yet a brief reference to it may not be out of place.

Gypsum, in its natural state, is a compound of sulphuric acid and lime with two equivalents of chemically combined water; and it has the following composition in one hundred parts:

Lime,	32.56
Sulphuric acid,	46.51
Water,	20.93
	100.00

When heated to 272° F. the mineral loses its water, and it is then known as *Plaster of Paris*, which is extensively used in making casts and cornices.

The value of gypsum in agriculture has been the subject of a great diversity of opinion—rather more with reference to the way in which it acts than on account of any doubt as to the beneficial results which follow its proper use. Liebig the great agricultural chemist, says that "The evident influence of gypsum upon the growth of grasses, the striking fertility and luxuriance of a meadow on which it is strewn, depends, *in some degree*, upon its fixing in the soil the ammonia of the atmosphere which would otherwise be volatilized with the water which evaporates."

It has been applied both directly as a fertilizer and indirectly in compost with ammoniacal and other manures. In each case the result has been beneficial, both by the direct supply of its own material for the nourishment of plants and by its influence upon the volatile carbonate of am-

monia, whether in rain water or manure, as already mentioned above.

While good results have been obtained on numerous crops, yet it has been found to be specially valuable for clover and grasses. The existence of large deposits of this valuable mineral will doubtless become of immense importance to the agricultural interests of Virginia when its true value becomes better known and more widely appreciated.

The quality of the gypsum is unusually fine, as shown by the analysis of samples selected by Mr. Thomas Jones from the Plaster banks of the Salt Works Company, at Saltville, Washington county:—

Lime,	32.293
Magnesia,	.151
Oxide of iron and alumina,	.149
Sulphuric acid,	46.445
Water,	20.856
Silicious matter,	.070
	99.964

CHAPTER IV.

Coal and Coke.

SECTION I.

Flat Top Coal Field.

The Flat Top coal field occupies a very large area of land in Tazewell county, Virginia, and in Mercer, Wyoming, McDowell and Raleigh counties, West Virginia. Of this large area the examination for this report was confined to the region now tributary to the completed (or now being completed) railroad lines of the Norfolk and Western Railroad Company.

This tributary area of coal land lies between the Flat Top Mountain on the north-west, the Bluestone river on the south-east, Laurel creek on the south-west and Widemouth creek on the north-east, embracing in all about forty square miles or over twenty-five thousand acres. It is practically owned and controlled by the South-West Virginia Improve-

ment Company, the Flat Top Coal Company, the Bluestone Coal Company and the Crane Creek Coal Company. The South-West Virginia Improvement Company are now extensively engaged in mining on their property on both sides of Coal Branch; and the other Companies have already concluded working leases by which a part of their coal areas will soon be developed.

The Flat Top Extension of the New River Division of the Norfolk & Western Railroad runs along Bluestone river from the mouth of Laurel creek to the mouth of Crane creek; then up Crane creek; and ultimately it is intended to cross (by tunnel) the Flat Top Mountain at Peters' Gap and follow the most desirable line—probably by the Pinnacle Fork of the Guyandotte—to the Ohio river.

The Flat Top coal region map (Plate No. 2) accompanying this report shows these railroad lines, and also shows how readily short branches from the main railroad line can be extended to develop the coal on the different streams emptying into the Bluestone between Laurel and Crane creeks.

The detailed examinations and report are confined to this limited area, because, Firstly, it is the only part of the region where the coals are opened for measurement and analysis; Secondly, it is the region now immediately tributary to the completed railroad line; and, Thirdly, because allowing ten thousand tons of coal per acre as the average yield of the Nelson, Pocahontas or No. 3 coal bed, a production of five thousand tons of coal daily from the region only uses one-half an acre of coal land daily; and the area described suffices for many years' production.

The *geographical position* of the Flat Top coal field is shown on map No. 1 accompanying this report. Taking the mouth of Laurel creek, or Pocahontas village, as the point of measurement, the coal is distant

75 miles from New River Junction (Central.)
90 " " Pulaski (Martin's.)

182 miles from Bristol.
207 " " Johnson City.
312 " " Knoxville.
423 " " Chattanooga.
120 " " Roanoke.
180 " " Buena Vista Ore Mines.
252 " " Milnes Furnace.
174 " " Lynchburg.
298 " " Richmond.
307 " " City Point.
378 " " Norfolk.

Three hundred and seventy-eight miles, therefore, places the coal on the shipping dock at Norfolk. For purposes of coal supply to the West India trade it has advantages over the Clearfield coal shipped from New York, the distance from the mines to the shipping dock being about the same.

The geographical map also shows approximately the distance to be traveled from the Flat Top Coal Field to the Ohio River.

Geologically, these Flat Top Coal beds belong to the lowest member of the Coal Measures, and are equivalent to the Seral or Pottsville Conglomerate of Pennsylvania, where the group seldom contains coal beds of economical importance.

The beds of this series were examined by Prof. Fontaine on the lower New River in West Virginia, and the name of Quinnimont Group was assigned to them by him. Later, the same series was studied somewhat in detail by Prof. Stevenson in the south-west counties of Virginia, as well as less closely along the waters of Laurel Creek in Tazewell county of Virginia. Mr. Lathrop, the Superintendent of the mines of the South-west Virginia Improvement Company, furnishes the following detailed section of the measures on Laurel Creek, at Pocahontas, partly measured above water level and partly taken from a bore hole record :

Top of ridge.
Concealed measures, ... 40′ 0″

Coal (No. 7,)			2′	0″
Concealed measures,			20	0
Coal (No. 6,)			1	6
Concealed,			80	0
Bone and dirt,	2′ 0″	*Coal*, (No. 5,)	4	6
Coal,	2′ 6″			
Concealed,			91	0
Coal (No. 4,)			2	0
Concealed,			90	0
Sandy fire clay,			6	0
Coal,	10′ 0″			
Slate,	0′ 3″	*Coal*, (No. 3,)	11	8
Coal,	1′ 0″			
Fireclay,			6	0
Shales and sandstone,			61	0
Coal,	1′ 0″			
Shale,	2′ 0″	*Coal*, (No. 2,)	4	0
Coal,	1′ 0″			
Concealed *to water level*,			12	6
(Below this level all measurements are taken from bore hole record.)				
Gray sandrock,			15	4
Coal (No. 1,)			1	0
Shale,			2	0
Sandstone,			27	6
Slate,			3	0
Gray sandrock,			35	4
Sandstone with coal streaks,			8	8
Sandstone and shale,			27	2
Gray sandstone,			4	0
" " and shale,			8	5
Fire-clay and shale,			8	10
Blue slate,			7	10
Sandstone and shale,			15	1
Gray sandstone,			17	0
Dark slate,			27	1
Blue sandstone,			26	3
" " very hard,			26	4
Slate,			1	0
Gray sandstone,			23	10
Dark shale, lighter colored below,			102	7
Gray sandstone,			3	0
Red shale and gray sandstone,			3	7
Gray sandstone,			2	0
Gray shale,			2	4
Gray sandstone,			1	6
Gray shale,			2	0
Red shale,			7	6
Bottom of bore hole,				
Total section,			841′	11″

Mr. Lathrop states that somewhat higher measures than those at the top of this section come in near the head of Laurel Creek, holding one or more coal beds.

The Quinnimont coal group attains its maximum importance in the vicinity of the Flat Top area. The beds are thick in Mercer and Raleigh counties of West Virginia, and in Tazewell county of Virginia; but eastward and westward the group diminishes in value. In south-west Virginia, in Wise, Scott and Lee counties, the coal beds of this series are insignificant, while north-eastward they soon become valueless; at the north-west, on the New River, the beds become much thinner, though the coal still remains excellent in quality.

These "Interconglomerate Coal Measures" have been fully described by Professor Stevenson of New York, and Professor Fontaine of West Virginia. The identifying fossil flora of these measures, and their thickening and thinning down at various points in Virginia and West Virginia are given in their Reports, and are not repeated here inasmuch as they are not needed in a Report upon the practical development of the Flat Top coal field; and moreover, they are easily accessible to all persons desiring the specific scientific information.

The coal measures in the coal field, so far as it was examined, seem to be nearly horizontal, the rise of the coal bed being no more than is needful for drainage. In the only mine worked so far (the Pocahontas) there is no water at all in the mine, in any part.

No faults were observed, though, of course, there may be small displacements of the steady level of the coal bed, which would not be seen on the surface and could only be be found in regular mining.

Topographically the coal field under description is very simple. The great Flat Top mountain, the most conspicuous and important feature, follows a somewhat winding course along the western and north-western side, and the Bluestone river skirts the south-eastern side. Numerous

streams start upon the mountain side, run rapidly down hill for a short distance as a brawling brook, and then follow a somewhat sluggish course, with moderate fall in their last few miles before reaching the Bluestone.

High ridges rise between these streams, holding the coal beds in them, and having the coal outcrops on their sides and south-eastern points. (See map No 2 of the coal field)

The stream valleys are narrow, usually with steep sloping sides, and present no special difficulties in the way of the development of the coal field.

The Bluestone river, at the mouth of Laurel creek, is 2270 feet above tide ; Peters' gap 2942 feet above tide, and the Flat Top mountain crest, near by, 3020 feet. The highest crest between Peters' gap and Windmill gap is 3416 feet above tide.

The quantity of coal in the Flat Top coal field is very great. In the area shown on plate No. 2 of this report, there are numerous openings on the Nelson or Pocahontas coal bed, (**No. 3** of the section,) and also some few openings on the upper beds, **No. 5** and **No. 6.**

Coal Bed No. 3, the Nelson or Pocahontas bed, is opened up on the outcrop on all, or nearly all, of the small streams between Laurel creek and Crane creek.

On *Coal Branch*, the Pocahontas bed (**No. 3**) has been extensively mined at the Pocahontas mines of the Southwest Virginia Improvement Company.

At these mines the bed has a sandstone and slate roof with slate floor. Its structure in No. 1 or East mine is as follows :

1. *Coal*, bony, (and not included in sample,)	0′	8″
2. *Coal*, with irregular thin slate streaks,	4	8
3. Slate, (not included in sample,)	0	0½
4. *Coal*,	6	0
5. Slate, (not included in sample,)	0	8
6. *Coal*,	1	0
Total thickness of bed,	12′	7″
Thickness of coal to be mined,	11′	8″

Samples for analysis were taken from the mine at different points as follows:

1. From the airway, and about ten feet from out-crop. 2. From first cross-entry, one hundred and fifty-three feet from out-crop. 3. Main entry, left side, one hundred and sixty-five feet from out-crop. 4. Main entry, left side, one hundred and eighty-five from out-crop. 5. From same, two hundred and eight feet from outcrop.

They yield:

Water,	.932
Volatile matter,	20.738
Fixed carbon,	73.728
Sulphur,	.618
Ash,	3.984
	100.000
Color of ash,	Cream.
Phosphorus,	0.0013

At the present time the Company are mining the large 6-foot bench of coal, leaving the upper 4′ 8″ coal bench in the roof and the 1′ 0″ coal bench in the floor, with the expectation of winning them both out hereafter, and thus mining over the whole area covered by their mines the whole 11′ 8″ of coal in the bed.

In actual working of the coal bed the small ½-inch slate parting is necessarily mined and shipped with the run of mine coal. A sample of the run of mine coal from the No. 1 or East mine as shipped to and used by the Shenandoah Valley Railroad analyzes as follows:

Water,	.684
Volatile matter,	19.964
Fixed carbon,	73.021
Sulphur,	.656
Ash,	5.675
	100.000

Color of ash, cream.

Coal Bed No 3 is also opened on the west side of *Coal Branch* at Mine No. 2 of the South West Virginia Improvement Company. In the face of the north entry the coal bed measures thus: (Lathrop)

Shale roof.			
Coal,	1′	6″	10′ 4″, all included in sample for analysis.
Hard rib of coal,	1′	8″	
Soft coal,	1′	1″	
Coal, with occasional hard streaks,	4′	3″	
Soft coal,	2′	3″	
Slate,	0′	4″	Not included.
Coal,	0′	11″	Included in sample.
Fire-clay floor.			

The sample for analysis as shown in the above section was taken from the face of the extreme west and north headings of the mine. It shows the following:

Water,	1.398
Volatile matter,	19.902
Fixed carbon,	71.171
Sulphur,	.834
Ash,	6.695
	100.000

Color of ash, cream.

The "hard rib of coal" 1′ 3″, shown in the upper part of the coal bed of the above section was analyzed separately, showing the following results:

Water,	.736
Volatile matter,	19.814
Fixed carbon,	70.370
Sulphur,	.765
Ash,	8.315
	100.000

Color of ash, reddish gray.

On *Mill Creek* the **No. 3 coal bed** passes below water level at a distance of 7050 feet above the Creek mouth. The level above tide at the mouth of the creek is 2244 feet; the tide level of the coal is 2462 feet, and the coal is therefore 218 feet above the Bluestone.

Capt. I. A. Welch measures this coal bed on Mill Creek as follows: Coal 9′ above bottom parting with $\frac{3}{4}$-inch parting at top. A sample for analysis was taken from the whole thickness of the coal bed, including the $\frac{3}{4}$-inch parting but leaving out the bottom parting. The sample was taken 7 feet in from the outcrop. It yields:

Water,	.492
Volatile matter,	19.278
Fixed carbon,	73.948
Sulphur,	.847
Ash,	5.435
	100.000

Color of ash, cream.

In this coal opening near the middle of the bed there occurs a 4-inch hard rib of coal or bone coal which was included in the sample analyzed above. A separate analysis of the *bone coal* shows it to contain:

Water,	.594
Volatile matter,	16.466
Fixed carbon,	62.189
Sulphur,	.601
Ash,	20.150
	100.000

Color of ash, cream.

On *Caswell Branch of Simmons' Creek*, **coal bed No. 3** has been opened for examination two miles from the mouth of Simmons' Creek and ¾ mile above the mouth of Caswell Branch. The roof proved tender and it was necessary to drive in 17′ to secure firm coal.

Capt. Welch reports the bed as showing 8′ of coal above the bottom parting of 18″ of bony coal, with a ½ inch of slaty coal near the top of the 8′ coal bench—the whole of this upper bench being included in the sample taken for analysis. It yields:

Water,	.768
Volatile matter,	18.532
Fixed carbon,	71.170
Sulphur,	.670
Ash,	8.860
	100.000

Color of ash, red.

On the hillside near the mouth of *Simmons' Creek*, and between 200 and 300 feet above the water level of the creek mouth, the bed shows:

Slate roof.	
Coal,	2′ 2″
Slate,	1 4
Coal,	6 6

Clay slate in floor not taken up. The 1′ 0″ bottom coal is supposed to underlie this clay slate.

The opening is only driven in a short distance from the outcrop, hardly sufficient to give a face of clean hard coal.

On the *East Fork of Simmons' Creek*, **coal bed No. 3** has again been opened for examination 1½ miles above the creek mouth. The water level at the creek mouth is 2226 feet above tide, and the coal takes cover at 2458 feet above tide, or 232 feet above the level at the mouth of the creek. At this point the coal bed shows:

Clay slate roof.	
Coal,	1′ 8″
Clay slate parting,	0 4
Coal, with ¼″ slate,	6 1
Fire-clay,	1 0
Coal,	0 2
Fire-clay floor.	

The specimen for analysis was taken by cutting the main bench of coal from top to bottom, including in the analysis the small and somewhat lenticular quarter-inch slate. The analysis shows:

Water,	.560
Volatile matter,	18.545
Fixed carbon,	74.683
Sulphur,	.712
Ash,	5.500
	100.000

Color of ash, red.

On a branch of the East fork of Simmons' Creek, **coal bed No. 6** is opened up on the outcrop. It shows:

Roof, clay slate.	
Bony *coal*, and *coal* useless and to be left in mining,	0′ 6″
Coal,	3 9
Fire-clay floor.	

The specimen for analysis represents an average of the 3′ 9″ coal, cut down from top to bottom. It shows the following results:

Water,	.568
Volatile matter,	19.337
Fixed carbon,	77.335
Sulphur,	.800
Ash,	1.960
	100.000

Color of ash, red.

On *Bell Branch* **Coal Bed No. 3** has not been sufficiently opened up for measurement and analysis. It goes under cover less than a mile above the stream mouth. The water level at the mouth of Bell Branch is 2219 feet above tide, and the coal takes cover at 2453 feet above tide or 234 feet above the level at the mouth of the stream.

On the West Fork of Flipping Creek, **coal bed No. 3** is opened up on the outcrop just where it passes under the water level of the creek, about 2½ miles above where Flipping Creek empties into the Bluestone. The water level at the creek mouth is 2205 feet above tide, and the coal goes under cover at 2400 feet above tide or 195 feet above the creek mouth.

The small parting which first shows between the benches of the coal bed at the opening on Simmons' Creek has here swelled out to a thickness of 8½ feet.

The upper bench was only partially opened up, and appears to be about 2 feet thick or somewhat more. The coal bed therefore shows thus:—

Clay slates overlying.
Upper coal bench—not fully opened up for measurement.

Clay slates,	8′ 6″
Coal, about,	6′ 0″

The lower part of the opening was somewhat covered up, and the specimen for analysis represents the top 4 feet of the large coal bench. The analysis shows:—

Water,	.516
Volatile matter,	17.689
Fixed carbon,	74.272
Sulphur,	.998
Ash,	6.575
	100.000

Color of ash, red.

On the West Fork of Flipping Creek, about 2 miles above its mouth, there is an opening on the outcrop of the **No. 5 coal bed,** driven in about ten feet from the crop. The exposure shows:

Sandstone.	
Thin bedded sandstone.	
Roof, clay slate.	
Coal,	5′ 5″
Floor, imperfectly seen, apparently fire-clay and slate.	

The coal shows no continuous slate partings, and an average of the whole bed was taken for analysis. It yields:

Water,	.786
Volatile matter,	18.939
Fixed carbon,	76.077
Sulphur,	.793
Ash,	3.405
Color of ash, red.	100.000

On the Tolliver Branch of Crane Creek there is an opening on the *lower bench* of **coal bed No. 3,** 4½ miles above the mouth of Crane Creek. The water level at the creek mouth is 2196 feet above tide, and the coal takes cover at 2395 above tide or 199 feet above the level at the stream mouth.

At this place the parting between the two benches has widened still more to a distance of 20 feet and **coal bed No. 3** is really two coals to be mined separately.

An opening on the *lower bench* just where it passes below the water level of the creek shows:

Clay slates overlying.	
Coal,	5′ 1″

with a small ¼-inch slate parting about 6 inches above the floor.

Floor, fire-clay.

The specimen for analysis represents the whole thickness of the coal bed including the small ¼-inch slate, and was taken from the face of the trial heading 15 feet in from the outcrop. The analysis shows:

Water,	.564
Volatile matter,	18.166
Fixed carbon,	72.147
Sulphur,	.683
Ash,	8.440
Color of ash, red.	100.000

On the south bank of the main branch of Crane Creek the *upper bench* of **coal bed No. 3** is exposed in a small ravine, 4 miles above the mouth of Crane Creek. It is almost the natural outcrop, a small stream running over it and the coal coming out to daylight remarkably firm and hard. It shows:

Roof, thin bedded sandstone.			
Coal,	1′ 1″	}	
Bony coal,	0′ 1″	}	4′ 8″
Coal,	3′ 1″	}	
Slate and clay floor.			

A complete section from top to bottom was cut down for analysis. It yields:

Water,	.600
Volatile matter,	18.020
Fixed carbon,	76.833
Sulphur,	.622
Ash,	3.925
	100.000

Color of ash, red.

These measurements are sufficient to show the average thickness of the large **No. 3 coal bed** and the two workable coal beds overlying it.

The large Pocahontas or Nelson coal (**No. 3**) should yield say 10,000 tons of coal to the acre.

The two upper workable coals (**No. 5 and No. 6**) will each yield probably fully 6000 tons of coal to the acre for the area covered by them, which is, of course, less than the area of the Pocahontas bed.

In view of these figures, it is useless to go into a computation of the total coal contents of the Flat Top coal field. Ten thousand tons daily product would only exhaust one acre daily of the Pocahontas bed, provided the 10,000 tons per acre estimate remains a fair average over the area examined.

It is obvious, therefore, that the region is a great storehouse of coal for steam making and coking purposes, and that the tonnage to be furnished to the Norfolk and Western Railroad Company is not now to be limited by any want

of coal in the region, but only by the limits imposed by the market for fuel.

The *quality* of the coals from the Flat Top coal field has been sufficiently well shown by the numerous analyses given in the preceding pages of this report. But in order to make a proper comparison with other standard coals, special samples have been taken, at the shipping point, of coals from well known collieries of the different regions shipping coal to tide-water. Careful analyses have been made of these specimens, and the results are grouped below.

Clearfield Coal.

	1.	*2.*	*3.*
Water,	1.338	1.166	1.054
Volatile matter,	22.122	22.299	22.081
Fixed carbon,	70.073	67.538	70.199
Sulphur,	.652	1.422	.726
Ash,	5.815	7.575	5.940
	100.000	100.000	100.000
Color of ash,	Cream.	Reddish gray.	Cream.

1. *Clearfield coal.* Sample taken from thirteen cars at Greenwich, Philadelphia.

2. *Clearfield coal.* Sample taken from five cars at Canton, Baltimore.

3. *Clearfield coal.* Sample taken from seven cars at Canton, Baltimore.

Cumberland Coal.

	4.	*5.*
Water,	.942	.974
Volatile matter,	18.403	19.876
Fixed carbon,	73.154	72.261
Sulphur,	.806	.769
Ash,	6.695	6.120
	100.000	100.000
Color of ash,	Reddish gray.	Cream.

Cumberland coal. Sample taken from coal supplied to Shenandoah Valley R. R. Company.

Cumberland coal. Sample taken from six cars at Greenwich, Philadelphia.

	6. Broad Top.	7. Westmoreland.	8. Cardiff.
Water,	.594	1.430	2.552
Volatile matter,	17.551	36.145	33.123
Fixed carbon,	71.334	55.891	56.774
Sulphur,	.976	.939	1.326
Ash,	9.545	5.595	6.225
	100.000	100.000	100.000
Color of ash,	Reddish gray.	Cream.	Reddish gray.

6. *Broad Top coal.* Sample taken from three cars at Canton, Baltimore.

7. *Westmoreland coal.* Sample taken from three cars at Greenwich, Philadelphia.

8. *Cardiff coal.* Sample taken from Guion steamship "Alaska" on her arrival at New York.

To make a more complete and accessible average of the quality of these coals as compared with those from the Flat-Top Coal field, they are grouped below in a single table, in which also has been included the analysis of the well-know Connellsville coking coal:

Name of Coal.	Water.	Volatile matter.	Fixed Carbon.	Sulphur.	Ash.
1. Flat-Top Coals—average of 10 samples,	.694	18.832	74.066	.761	5.647
2. Flat-Top Coals—average of 8 samples, No. 3 Coal Bed,	.698	18.756	73.406	.752	6.388
3. Cumberland coal—average of 2 samples,	.958	19.139	72.708	.787	6.408
4. Clearfield Coal—av. of 3 samples,	1.186	22.168	69.270	.933	6.443
5. Broad Top Coal,	.594	17.551	71.334	.976	9.545
6. Connellsville Coking Coal,	1.260	30.107	59.616	.784	8.233
7. Westmoreland Coal,	1.430	36.145	55.891	.939	5.595
8. Cardiff Coal, Wales,	2.552	33.123	56.774	1.326	6.225

While the analysis of a coal affords a fair opportunity of judging of its character as a steam coal, yet there are so many points connected with its physical structure and

coking qualities which an analysis cannot show, that a practical testing under boilers is of the highest importance. Such a practical testing has recently been carried out on the Shenandoah Valley Railroad. Weighed quantities of the Flat Top coal have been carefully tested alongside of similar quantities of other standard fuel, with the result of endorsing in the highest degree the calorific efficiency of the Flat Top coal.

The tests were made under the direction of Mr. Chas. Blackwell, the Superintendent of Motive Power of the Norfolk and Western and Shenandoah Valley Railroad Companies, and were conducted personally by Mr. Richard P. C. Sanderson, whose report, kindly furnished by Joseph H. Sands, Esq., General Manager of the Railroad Companies, is herewith submitted.

In connection with this report it may prove interesting to compare the analyses of the two coals tested. That of the Flat Top Coal is given on page 111, and the Cumberland Coal on page 118.

Tests of Pocahontas (Flat Top) and Cumberland Coal.

Report of Engine and Coal Trials.

* * * * * Having executed a carefully conducted series of tests of each of the classes of engines in use on the Shenandoah Valley Railroad with Pocahontas and with B. & O. Hampshire coal, I beg to report the following results:

Coal and Water Consumption.—The annexed tables give the average of car miles (two empties=one load,) ton miles, pounds of coal per car mile, pounds of coal per ton mile, and equivalent evaporation at 212° Fahrenheit in pounds of water per pound of coal. Beyond mentioning that the three trips made when the conditions of weather were unfavorable have been left out of the results tabulated, these tables will speak for themselves and need no further comment.

Sheet No. 1.

March, *Shenandoah Valley Railroad.* 1884

Engine and Coal Tests. Total No. of Pass. Trials, 8. Total No. of Freight Trials, 24. *Pocahontas Coal.* Average of Results.						Engine and Coal Tests. Total No. of Pass. Trials, 8. Total No. of Freight Trials, 24. *Hamp. and Balto. Coal.* Average of Results.					
ENGINE 22.	Car miles.	Ton miles.	Lbs. coal per car mile.	Lbs. coal per ton mile.	Equivt. evaporation at 212° in lbs. water per lb. of coal.	ENGINE 22.	Car miles.	Ton miles.	Lbs. coal per car mile.	Lbs. coal per ton mile.	Equivt. evaporation at 212° in lbs. water per lb. of coal.
Through freight, .	1,812	44,316	7.5	0.309	5.16	Through freight, .	1,989	39,403	7.92	0.389	4.93
Local " .	1,992	39,595	7.14	0.360	4.53	Local " .	1,756	38,870	8.94	0 402	4.44
ENGINE 44.						ENGINE 44.					
Through freight, .	2,689	66,687	4.99	0.202	10.05	Through freight, .	2,490	62,955	6.54	0.274	7.85
Local " .	2,538	57,929	5.12	0.235	8.91	Local " .	2,820	58,919	5.80	0.285	7.17
ENGINE 8.						ENGINE 8.					
Pass. trains, . . .	779	20,094	9.8	0.418	9.7	Pass. trains, . .	779	20,094	12.8	0.512	6.53

Average per cent. of Cinder and Ash per Ton of Coal.

Engine 44, Pocahontas, ...	4.98	Engine 44, Hamp. and Balto., ...	7.40
Do. 8, do.	1.05	Do. 8, do.	1.47

This table shows the net coal used for the actual haul from coupling up to cutting loose, leaving out all coal used during layovers; the water-level, steam pressure and depth of fire on bars being practically the same at each trial when taking hold and letting go.

SHEET NO. 2.

March, *Shenandoah Valley Railroad.* 1884.

Engine and Coal Tests. Average of Results.
Total No. of Pass. Trials, 8. Total No. of Freight Trials, 24.
Pocahontas Coal.

ENGINE 22.	Car miles.	Ton miles.	Lbs. coal per car mile.	Lbs. coal per ton mile.	Equivt. evaporation at 212° in lbs. water per lb. of coal.
Through freight, .	1,812	44,316	7.98	0.326	5.16
Local " .	1,992	39,595	7.59	0.385	4.53
ENGINE 44.					
Through freight, .	2,689	66,687	5.42	0.219	10.05
Local " .	2,538	57,929	5.66	0.247	8.91
ENGINE 8.					
Pass. trains, ...	799	20,094	11.3	0.453	9.7

Engine and Coal Tests. Average of Results.
Total No. of Pass. Trials, 8. Total No. of Freight Trials, 24.
Hamp. and Balto. Coal.

ENGINE 22.	Car miles.	Ton miles.	Lbs. coal per car mile.	Lbs. coal per ton mile.	Equivt. evaporation at 212° in lbs. water per lb. of coal.
Through freight, .	1,989	39,403	8.31	0.394	4.93
Local " .	1,756	38,870	9.29	0.419	4.44
ENGINE 44.					
Through freight, .	2,490	62,955	6.61	0.28	7.85
Local " .	2,820	58,919	6.54	0.301	7.17
ENGINE 8.					
Pass. trains, . . .	799	20.094	13.9	0.556	6.53

Average per cent. of cinder and ash per ton of coal.

Engine 44, Pocahontas, ...	4.98
Do. 8, do.	1.05
Engine 44, Hamp. and Balto., ...	7.40
Do. 8, do.	1.47

This table includes the coal used in firing up and consumed in lay-overs when not excessively long.

Percentage of Ash and Cinder.—In reference to this, I would mention that the results obtained with engine 44 are alone worth considering, for the reason that in this case alone were the whole—or nearly so—of the cinders and ashes deposited in the ash-pan. In the other cases, owing to the smallness of the grate area, the draught was so fierce that a large percentage of cinder and ash was carried out through the stack.

Description of the Engines.—All engines have extended front, and brick arch.

Engine 22.—Class, ten wheels—six wheels coupled; freight; diameter of cylinder, 18″; stroke, 24″; diameter of driving-wheels, 51″; ordinary D valve; travel, 4⅛″; outside lap, ⅞″; inside lap, 1/16″; lead at full stroke, 5/64″; area of fire-grate, 15.1 square feet; area of heating surface, 804 square feet.

Number of tubes, 140; diameter of tubes, 2¼″; length of tubes, 12′ 9″; smallest diameter of shell, 48″; wagon-top boiler; diameter of nozzle, 3⅞″ single; diameter of stack, 16″ straight.

Engine 44.—Class, consolidation; freight; diameter of cylinder, 20″; stroke, 24″; diameter of driving-wheels, 50″; counterbalanced Allen valve 5″ travel; ⅞″ outside lap; full line and line inside; 1/32″ lead at full stroke; area of fire-grate, 29.8 square feet; area of heating surface, 1482.5 square feet.

Number of tubes, 174; diameter of tubes, 2¼″; length of tubes, 13′ 1″; smallest diameter of shell, 56″; flush-top boiler; diameter of nozzle, 3½″ double; diameter of stack at bottom, 17½″, tapering to 21″ diameter at top.

Engine 8.—Class, eight wheels—four wheels coupled—passenger; diameter of cylinder, 17″; stroke, 24″; diameter of driving wheels, 63″; ordinary D valve; 5 3/16″ travel; ⅞″ outside lap; 1/32″ inside lap; lead 1/16″; area of fire-grate, 15.8 square feet; area of heating surface, 1016 square feet.

Number of tubes, 161; diameter of tubes, 2″; length of tubes, 10′ 10½″; smallest diameter of shell, 47″; wagon-top boiler; diameter of nozzle, 2⅞″ double; diameter of stroke, 16″ straight.

General features of track:

Laid with fifty-six-pound steel rail on southern division over which freight engines were tried. Laid partly with steel and partly with iron on northern division. General condition, fairly good. The average curve of the road is 4° 10′. The sharpest, 10°. The two steepest grades on the southern division are as follows:

Going north—grade 54.9 feet per mile for 1,290 feet, with a 7° curve.
grade 79.2 feet " " " 15,500 feet, " " 6° "
Going south—grade 79.2 feet " " " 14,700 feet, " " 6° "
grade 79.2 feet " " " 17,390 feet, " " 8° "

On the northern division the steepest grade going north is 84.48 feet per mile for 0.19 miles.

The steepest grade going south is 89.76 feet per mile for 0.88 mile.

Sum of ascents going north, 4,150.81.
" " " " south, 4,482.06.

Straight lines, 156.03 miles.
Curves, 81.56 miles.

General remarks concerning the coals used.

Pocahontas coal. This coal makes a very bright hot fire. It cokes on the grate even when slack is used, and but a small proportion is carried off the grate by the draught. It does not need much hooking up. One trip on No. 8 was made between Roanoke and Hagerstown—two hundred and thirty-nine miles—without a hook being put into the fire.

The trains never stalled for the want of steam on the heaviest grades, and the engines throw much less fire than with the B. and O. coal.

The injectors could be kept full on when climbing the grades without causing the steam pressure to fall; and the steam pressure could be kept at blowing off point when the engines were working their hardest without particular difficulty.

B. and O. Hampshire coal. This coal does not make such a hot fire as the Pocahontas coal. There was always a dull lurid appearance, contrasting markedly with the white hot hue of the Pocahontas coal fire. This B. and O. coal burns into holes, and requires constant hooking and leveling. The dust coal seemed to fly right off the shovel

out through the stack. With a light fire the coal seemed to be dancing on the grate, and would not coke as the Pocahontas coal did.

The trains frequently stalled for want of steam on the grades. It was invariably necessary to use the blower when the engines were pulling their hardest; and with the freight trains it was no infrequent occurrence for the engineer to have to stop on the grades to fill up the boiler and get up the steam pressure, as the use of the injectors would run the steam pressure down very rapidly. The engines all threw more fire when using this coal, and the front ends would generally be packed full of sparks at the end of the trip.

The amount of clinker made with both coals was much about the same, the quantity being insignificant, and the clinkers being soft and easily crumbled in the hand.

General remarks concerning the engines.

Under this head I would mention that the consolidation engines should, in my estimation, be rated at five more loads than the six-wheeled coupled engines are rated at. When they have more than this to pull they are very severely strained. The consolidation engines burn less coal and haul a heavier train than the six-wheel coupled engines for the same engine mileage.

I attribute the wastefulness of the engines 22 and 8 as compared with 44 to the smallness of the fire-grate area and consequent fierceness of the draught per square foot of fire grate, which carries a large percentage of the small coal in an almost unburned condition out through the stack. This is especially noticeable when the B. and O. coal was used. A regular hailstorm of half-burned coal followed the throwing on of each shovelful of coal, and the pyrotechnic display at night, although very edifying, was highly dangerous to the property adjoining the track, and was, it is needless to remark, a misapplication of the fuel.

In conclusion, I would mention that I purposely misled each crew with regard to the coal they were burning, so as to see if the increased consumption were at all due to the prejudice of the men against either of the coals, which

would make them wasteful and careless, but found that this was not the case.

Such analyses of the Flat Top coal as have been given in the body of this report and such tests of practical working under boilers as are given above call for but little comment. It is plain that the Flat Top coal can be shipped to any market fairly within its reach for sale as a steam-raising fuel in competition with any of the standard coals mined in this country.

For coking purposes the Flat Top coal has proved a very efficient fuel. Thousands of tons have been coked at Pocahontas in bee-hive ovens, and shipped to furnaces and foundries. The Crozer Steel and Iron Company's large 100-ton furnace at Roanoke has run on this coke for nearly a year, and Col. D. F. Houston, the general manager, says of it:

"We have been using coke made from the Flat Top coal at Pocahontas for the past ten months and find it equal to Connelsville coke which we used the first two months of our blast. We have no difficulty in carrying two pounds of ore for one pound of coke in our burden."

Such testimony should be sufficient to show the burden-bearing power of this fuel in the furnace stack and its calorific efficiency.

This is of great importance in the future development of south-west Virginia as an iron making region, as it brings the necessary cheap and good fuel within convenient distance of the large supplies of iron ore already described as accessible on New River, Cripple Creek and elsewhere.

The shipments of coal and coke from the Pocahontas colliery of the South-West Virginia Improvement Company have already been as follows:

From May 1st, 1883, to January 1st, 1884, 54,552 tons of coal and 23,762 tons of coke; and from January 1st, 1884, to May 1st, 1884, 34,817 tons of coal and 13,820 tons of coke, making a total shipment of 89,369 tons of coal and 37,582

tons of coke. The mines are now in shape for a much larger shipment as the market may call for it.

The Norfolk and Western Railroad company are now making very extensive improvements and shipping docks at Norfolk for the purpose of handling the expected large increase in tide water shipments of Flat Top coal.

The cost of mining and placing upon the railroad the coal from the Pocahontas Coal (**bed No. 3**) should compare favorably with the mining and shipping of the standard steam and coking coals of the country.

The coal lies well for mining. The outcrop sweeps smoothly around the points of the ridges overlooking the Bluestone and along the sides of the ravines of the streams leading into it. From one to two and a half miles up these streams the outcrop touches the stream level, some 200 or more feet above the level of the Bluestone. The coal is lying nearly horizontal, and thus offers most favorable opportunities for the easy location of collieries and the economical working of the coal, entirely above water level, without water pumping and with cheap access to the New River Division and the Flat Top Extension of the N. & W. RR.

There is an ample supply of suitable timber on all the streams leading into the Bluestone to furnish all that will be required in mining operations.

At the present rate of wages the cost of putting *run of mine coal* upon the cars—with 6 or 7-foot bed of clean coal, good roof and floor, and free from faults—should not exceed 60 cents per ton, actual cash outlay. This applies to the Pocahontas coal bed. The cost of mining the upper coals, somewhat smaller in size, would perhaps somewhat exceed this amount.

Unless there be some special value to the smaller coal beds in their exceptional character, it may be expected that the mining for a considerable period will be chiefly confined to the Pocahontas **coal bed No. 3.**

On Mill Creek, Bell Branch, Simmons' Creek, Flipping Creek, and their branches, the large coal bed can now be

easily attacked and collieries planted directly tributary to the Norfolk and Western Railroad.

The cost of much of the material for the necessary plant for collieries and coke ovens is probably somewhat less than the cost for the same material in most of the other coal and coke regions, and labor is abundant and at fair prices.

Market for the Coal and Coke. It having been shown that the coal exists in great quantity in the Flat Top Coal field; that it is of excellent character; that it lies favorably for easy opening up of collieries and for economical mining; and that the Norfolk and Western Railroad runs close to these mining locations, rendering them available for use immediately; the question arises, what is the present market for this coal and coke, and what is the reasonable prospect for increase and widening out of such market?

The market for coal is

1. The railroad demand for locomotive use on the Norfolk and Western and Shenandoah Valley Railroads—the combined system embracing 800 miles of railway.
2. Local sales along these railroad lines and in the regions tributary to them.
3. Sales on the line of the Norfolk and Western Railroad should extend as far south-west as Chattanooga.
4. Sales on the Norfolk and Western Railroad at Lynchburg and points eastward.
5. Sales along the lines of the Virginia Midland, Richmond and Danville and Seaboard and Roanoke railroads, including the Richmond market to which the Flat Top coal is nearer by 30 miles than its present supply.
6. Tide-water market at Norfolk.
7. Sales on the Shenandoah Valley Railroad can go north-east until they reach the region fully supplied by the Cumberland coal.

The Coke market is

1. For present use on the line of the Norfolk and Western and Shenandoah Valley Railroads.

2. For future use along the RR. line when the opening up of the supply of rich Cripple Creek iron ore shall have made that region a large and steady producing pig-iron district. An increasing and profitable coke trade may be properly looked for: for coke is the typical blast furnace fuel; and the rates of its increased market in South-west Virginia may be expected to exceed the ratio of increased coal consumption. The coke trade should spread south-west until it meets the Alabama coke and north-east until it meets the Connellsville coke—at such points as would give these latter fuels decided advantages in distance of transportation.

It is not within the scope of this report to work out more specific details. The probable increase in tide-water shipments from Norfolk and other extensions of the market in the directions named are sufficiently obvious.

SECTION II.

Coals in the Measures Underlying the Carboniferous System Proper.

In several counties of South-West Virginia there are other coal beds of a different character and occurring in a different geological horizon, underneath the Coal Measures *proper*. These have already been referred to on page 13 of this report, and they are not sufficiently important to require further detailed mention here.

Although they will doubtless prove important for local use in blacksmith shops and for domestic purposes, yet, apart from other considerations, the large percentage of ash which they invariably contain will prevent their being used to any great extent for metallurgical purposes, especially in the manufacture of pig-iron.

The following analyses of specimens from Montgomery, Pulaski and Wythe counties will show their composition:

Montgomery County.

1. *Guggenheim bank*, Smith & Slusser, lessees, on Brush

Mountain near head of Tom's Creek, four miles north-east from Blacksburg, Sampled by W. W. Coe.

2. *Smith bank*, mined by Elmore & Smith, on lands of Giles J. Henderson; four miles north-east from Blacksburg. Total thickness of bed, five feet, with about one foot of slate in three partings. Sampled by W. W. Coe.

3. On lands of *Blacksburg M. & M. Company*, in Faulkner Hollow four miles west from Blacksburg. Bed four and one half feet thick, as follows: Twenty-six inches of top coal, two inches slate, ten inches coal, two inches slate and twelve inches coal. Specimens show the *top coal*. W. W. Coe.

	1.	2.	3.
Water,	1.228	.816	.615
Volatile matter,	11.652	11.324	12.870
Fixed carbon,	73.012	75.618	70.924
Sulphur,	.548	.697	.481
Ash,	13.560	11.545	15.110
	100.000	100.000	100.000

4. On lands of *William Perfator*, half a mile from the mouth of Poverty Branch and eight miles west of Blacksburg; Brush Mountain. Samples taken from pile of screenings at mouth of mine, from little or middle bed about two feet thick. W. W. Coe.

5. On lands of *William Meyers*, on eastern slope of Price Mountain, three miles south from Blacksburg. Samples of *hard* coal from top of bed. Total thickness of bed about two feet, showing about fifteen inches of hard coal on top.

	4.	5.
Water,	.725	1.080
Volatile matter,	12.215	9.675
Fixed carbon,	72.737	74.013
Sulphur,	.333	.682
Ash,	13.990	14.550
	100.000	100.000

Pulaski County.

From *Altoona coal mines*, eight miles from Pulaski station on the Norfolk and Western Railroad. Samples selected by Mr. Thomas Jones, Superintendent of the Zinc Works at Pulaski. An analysis shows:

Water,	.236
Volatile matter,	9.459
Fixed carbon,	49.353
Sulphur,	1.122
Ash,	39.830
	100.000

Wythe County.

On *Little Walker's Mountain* near Stony Fork of Reed Creek, and near water level of creek, seven miles north-west from Wytheville. *Seam No. 2;* average thickness, three feet. Sample from pile of freshly mined coal at mouth of drift.

Same general locality. *Seam No. 4;* average thickness, two feet. Sample from pile of coal at mouth of drift which had been exposed to the weather for one month.

	Seam No. 2.	*Seam No. 4.*
Water,	.466	.620
Volatile matter,	16.264	17.853
Fixed carbon,	55.615	59.427
Sulphur,	.995	1.575
Ash,	26.660	20.525
	100.000	100.000

CHAPTER V.

Miscellaneous Minerals.

Umber.

Half a mile east from the Shenandoah Valley Railroad, and near Major Overall's house, a valuable deposit of umber has been opened up in the face of a hill, and some of it mined for local use. When examined the deposit showed a face eight by five feet, of a seemingly uniform character throughout. Samples across the entire face were selected for analysis and for practical tests. These latter have been made by competent experts, and they pronounce it to be one of the finest specimens of native umber in the market. A chemical analysis shows it to contain:

Silica,	31.640
Alumina,	13.510
Sesquioxide of iron,	34.000=23.800 parts metallic iron.
Sesquioxide of manganese,	6.209= 4.323 parts metallic manganese.
Lime,	.720
Magnesia,	1.657
Alkalies and undetermined,	8.390
Water,	8.874
	100.000

About one hundred tons of this umber have since been mined and shipped to markets in Pennsylvania.

Ochre.

Near Marksville, on the line of the Shenandoah Valley Railroad, the Oxford Ochre Company is working an extensive deposit of ochre, and shipping varying amounts to the different markets of the country. The ochre is said to be of a very light brown color, of good quality, and to find a ready sale.

The following table will show in detail the shipments during the past two years: From June 1, 1882, to June 1, 1883, four hundred and twenty tons, and from June 1, 1883, to June 1, 1884, six hundred and forty-four tons, a total of one thousand and sixty-four tons during the past two years, as follows:

Ochre from Marksville in tons of two thousand pounds.

June,	1882,	22
July,	"	62
August,	"	14
September,	"	61
October,	"	36
November,	"	15
December,	"	19
January,	1883,	2
February,	"	33
March,	"	42
April,	"	64
May,	"	50
June,	"	56
July,	"	36

August,	1883,	53
September,	"	47
October,	"	54
November,	"	21
December,	"	122
January,	1884,	12
February,	"	25
March,	"	68
April,	"	66
May,	"	84

Fire-Brick and China-Clay Works.

The Virginia China-Clay and Fire-Brick Company's works are situated near Lipscomb station on the line of the Shenandoah Valley Railroad, south of Waynesboro'. They are reported to be making at present 3000 brick and washing about eight tons of China-clay per day; but it is expected that this output will be largely increased in the near future.

At present they employ fifty men at the works. The plant consists of three down-draft kilns, (one of which is in operation, and the other two just about completed,) each having a capacity of 42,000 brick every fifteen days, equal to 252,000 brick per month. They have made a contract for the building of two more kilns of the same capacity, which will bring the total capacity up to 420,000 brick per month. A small branch road is now being constructed from the main line of the S. V. R. R. to the works, which will greatly facilitate future shipments.

The establishment of works which will make a quality of brick suitable for blast-furnaces and coke-ovens is a most important matter in connection with the development of the mineral resources of Virginia.

Through the courtesy of the Harrisburg Fire-Brick Works Company, P. G. Wikel, Supt., I have been able to test a sample brick made at Lipscomb. The result has been very satisfactory, showing a very refractory quality of fire-brick.

The *China-clay* is beautifully white, and seems to be of good quality and quite free from grit. The principal present market for this is East Liverpool, Ohio.

Tin Ore in the Blue Ridge.

During the past year there has been considerable prospecting for tin ore on Irish creek of the South river of the James, in Rockbridge county, Virginia, about eight miles S. E. from Vesuvius station on the Shenandoah Valley Railroad. The first openings were made on the Cash lands, on the side of a ravine of a small stream leading into Irish Creek, and showed at one point some two inches of a very rich tin ore, (Cassiterite.) The opening is in the crystalline rocks underlying the Potsdam sandstone, (No. 1 of our geological nomenclature,) and these rocks are here nearly vertical, much twisted and contorted, and have a general course or strike at this point of about N. 25° E., and S. 25° W. The rocks consist for the most part of quartz, feldspar, (orthoclase and albite,) hornblende, and, at a few points, mica schist. The opening was very small, and not carried to any considerable depth. The ore which showed in the trench was very rich, and was sometimes associated with mispickel carrying more or less silver and gold.

Numerous trial-pits have been sunk through the region lying south-west of this opening, and Messrs. Robertson Bros., Lynchburg, report that in one case they have opened a deposit of ore which yielded on analysis 3.25 per cent. metallic tin. (The analysis was made by Col. Hardin, Lexington.) The discovery of any considerable quantity of ore yielding as high as 3.25 per cent. metallic tin is a matter of importance, and its value is sufficient to stimulate a thorough prospecting of the region.

CHAPTER VI.

Summary of Results.

But little need be added to what has already been said in regard to the *iron ores*. The analyses speak for themselves. They show the average quality of the ores to be good ; and in some localities they are remarkably rich and pure.

Shenandoah Valley Ores.

The average of thirty-four samples of the *brown hematite ores* (excluding the *manganiferous ores*) from the Shenandoah Valley, shows the following:

Metallic iron,	48.839
Phosphorus,	.477
Phosphorus in 100 parts iron,	.976

Of these, seven samples represent very cold-short ores, which would be specially adapted for the manufacture of pig-iron for conversion into steel by the "*basic process.*" They show an average composition as follows:

Metallic iron,	49.580
Phosphorus,	1.322
Phosphorus in 100 parts iron,	2.666

Omitting these from the calculation, we get the following, which will perhaps show more accurately the general average character of the Shenandoah Valley ores:

Metallic iron,	48.646
Phosphorus,	.259
Phosphorus in 100 parts iron,	.532

Cumberland Valley Ores.

As a means of comparison, it may be added that the analyses of forty-six specimens from the continuation (northward) of the same ore belt through the Cumberland Valley, Pennsylvania, show the following average composition:

Metallic iron,	42.950
Phosphorus,	.464
Phosphorus in 100 parts iron,	1.080

Lehigh Valley Ores.

When to the above is added the fact that the brown hematite ores at present being mined in the Lehigh Valley will not yield *over* forty per cent. iron in the blast-furnace, it will be seen that the ores of the Shenandoah Valley rank high.

New River and Cripple Creek.

Along New River and Cripple Creek in south-west Vir-

ginia, there is an iron ore belt in the body of the Great Limestone Formation No. II, which yields ores of remarkable purity and seemingly in great abundance. For a distance of twenty-five or thirty miles the ore possesses great uniformity in character. The average of seventeen samples of these *limestone ores* shows the following:

Metallic iron,	54.514
Phosphorus,	.106
Phosphorus in 100 parts iron,	.194

Only one sample shows less than fifty per cent. metallic iron; and in no case is the phosphorus over .20. While perhaps only a few of them can be used *per se* for the manufacture of Bessemer pig-iron, nearly all of them would be found sufficiently low in phosphorus to be valuable for mixing with more refractory Bessemer ores.

Red Hematite and Magnetite in the Lower Silurian Limestones.

Another group of ores in the limestone formation (see Section IV) deserves special notice on account of their remarkable richness and purity. They may be said to be as yet practically undeveloped; for the ores were found to be too refractory for the small cold-blast charcoal furnaces of the district, and a lack of railroad facilities prevented their finding an outside market. Should they be found to exist in large quantities—and there is good reason for hoping this—the deposits will undoubtedly be extensively worked, for the ores are of the finest quality and are especially adapted for the production of a high grade of Bessemer iron. The analyses of nine samples of the *red hematite and magnetite* show the following average:—

Metallic iron,	62.090
Phosphorus,	.032
Phosphorus in 100 parts iron,	.051

The brown hematite ores which are sometimes found accompanying them are equally pure, especially in regard to phosphorus. An average of four samples shows:

Metallic iron,	54.532
Phosphorus,	.031
Phosphorus in 100 parts iron,	.056

Bessemer ores.

As the question of a supply of "Bessemer ores" is one which is now receiving considerable attention, the following table may prove serviceable. It contains the analyses of ores which from their contents of iron and phosphorus, may be classed as Bessemer ores. Only those are included which show not over .14 parts of phosphorus in one hundred parts iron, which would be equal to about 0.130 per cent. phosphorus in the pig-iron—an amount which is considered a maximum:

Bessemer ores.

NAME.	Character of ore.	Iron.	Phosphorus.	Phos. in 100 parts iron.
1. Thomas bank,	Red hematite,	65.050	.021	.032
2. McDaniel,	Red and brown hematite,	57.375	.020	.034
3. Crockett,	Red hematite,	64.650	.022	.034
4. Crockett,	Limonite,	55.650	.020	.036
5. Sharp,	Red hematite,	65.550	.026	.039
6. Garrett,	Limonite,	56.080	.023	.041
7. Price bank,	Red hematite,	61.000	.028	.046
8. Garrett,	Red hematite,	66.470	.032	.048
9. Cowan,	Limonite,	57.625	.029	.050
10. Harman,	Limonite,	55.225	.029	.052
11. Golleher,	Magnetite,	56.050	.036	.064
12. Ripplemead or Johnson,	Magnetite,	63.550	.051	.080
13. Preston,	Red hematite,	59.150	.049	.083
14. Rose,	Limonite,	51.700	.043	.083
15. Van Liew; *lump ore*,	Limonite,	56.500	.048	.085
16. Robinson,	Limonite,	56.450	.061	.108
17. Pack's Tunnel,	Limonite,	48.825	.054	.110
18. Crigger,	Limonite,	53.725	.064	.119
19. Bear,	Limonite,	49.400	.062	.125
20. Pierce,	Limonite,	57.200	.074	.129
21. Houston No. 4 opening,	Limonite,	47.150	.061	.129
22. Van Liew; *wash ore*,	Limonite,	51.600	.068	.131
23. Alexander, Neitch & Roland,	Red hematite,	56.800	.075	.132
24. Forney or Rich Hill,	Limonite,	53.350	.075	.140
25. Champ Shephard,	Limonite,	49.800	.071	.142

While some of the ores are sufficiently rich and pure to

bear *long* transportation to markets, yet the bulk of them can be more economically utilized in furnaces built at convenient points along the lines of your railroads; and the establishment of such enterprises in the near future seems now well assured.

Eligible sites for blast furnaces are fortunately numerous; and already a large coke furnace is in blast at Roanoke; and others are projected at Pulaski and other well-located points on the main line of the Norfolk and Western Railroad. Furnaces at these points would draw their supply of ores chiefly from south-west Virginia, and probably also from Tennessee, and from "Cranberry" and other mines in North Carolina; from the local deposits near Pulaski; from the immediate vicinity of Roanoke, and from the lower end of the Shenandoah Valley—the Roanoke-James River Valley.

Along the Cripple Creek extension of the Norfolk and Western Railroad large coke furnaces could be built to great advantage to smelt the rich brown hematites so plentiful in that section; and these ores will be shipped in large quantities for the use of any blast furnaces erected along the main line of your railroads.

Along the line of the Shenandoah Valley Railroad good sites for the erection of blast furnaces are equally numerous; and of these, Buchanan, Port Republic and Milnes—the latter with Iron Works already in successful operation—may perhaps be considered among the most valuable, having a good supply of ores within convenient distance.

All of these localities are in the midst of a rich agricultural country amply able to provide for all the wants of an industrial community, and with an abundant and never-failing water supply.

That a good quality of neutral pig-iron can be made at these points at a minimum cost, there can be no doubt; and the following carefully-prepared estimates* will show that this section can successfully compete with other local-

* Estimates are based, of course, on the erection of large modern coke furnaces; with coke at $1 75 per ton at Pocahontas, and freight rates of not over one cent per gross ton per mile.

ities where at present large iron industries are in a prosperous condition.

Through the courtesy of L. S. Boyer, Esq., Secretary of the Shenandoah Iron, Lumber, Mining and Manufacturing Company, I have been furnished with the following data, showing the *actual* cost of making coke pig-iron at Milnes on the Shenandoah Valley Railroad, in the spring of 1883. Mr. Milnes, President of the Company, under date of April 8, 1884, says: "As to the cost of making pig-iron, I do not think it necessary to make any changes."

Cost of Making Iron at Milnes.

Ore, 2¼ tons, @ $2 00,	=$4 50
Coke, 1¼ tons, @ $4 20,	= 5 25
Limestone,	30
Labor,	1 50
Incidentals,	1 00
Total cost per ton,	$12 55

Estimated Cost at Buchanan.

Ore, 2¼ tons, @ $2 10,	=$4 73
Coke, 1⅜ tons, @ $3 25,	= 4 46
Limestone,	60
Labor,	2 00
Incidentals,	1 25
Total cost per ton,	$13 04

The following is a carefully prepared estimate of the cost of making pig-iron at Roanoke:

*Estimated Cost at Roanoke.**

Ore, 2⅛ tons, @ $2 25,	=$4 79
Coke, 1¼ tons, @ $2 95,	= 3 69
Limestone,	75
Labor,	2 10
Incidentals,	1 25
Total cost per ton,	$12 58

*Since the above was written, an estimate by Colonel Houston, General Manager of the Crozer Steel and Iron Company, makes the cost of pig-iron at Roanoke $12 60 per ton.

Estimated Cost at Pulaski.

Ore, 2½ tons, @$2 25,	= $4 79
Coke, 1¼ tons, @$2 65,	= 3 31
Limestone,	60
Labor,	2 00
Incidentals,	1 25
Total cost per ton,	$11 95

The cost on Cripple Creek should not exceed $11 per ton, as follows:

Estimated Cost on Cripple Creek.

Ore, 2⅛ tons, @$1 60,	= $3 40
Coke, 1¼ tons, @$3 10,	= 3 88
Limestone,	50
Labor,	2 00
Incidentals,	1 25
Total cost per ton,	$11 03

It is believed that these estimates will fairly represent what can be accomplished in practical working operations, showing that pig-iron can be made at a cost of about $12 per ton. In each case the labor and incidentals have been charged at $3 25 per ton, which is probably in most cases too high, for in actual practice at Milnes these items are given as only $2 50.

For comparison, the following figures have been obtained from prominent Iron Masters in different sections of Pennsylvania and elsewhere, giving the *actual* cost of making pig-iron at numerous points during the year 1882.

Owing to the reduced price of both ore and fuel, the cost of making pig-iron during the year 1884 will be much less. In some cases this decrease in cost will amount to fully $2 per ton. I have, therefore, added an *estimate* of the cost of production during 1884; and in order to make a proper comparison with the estimates given for furnaces along the lines of your railroads in Virginia, I have in every case estimated labor and incidentals at $3 25.

While it is true that iron can be made cheaper than in the estimates I have given, wherever the furnaces use *mill*

cinder as part of their burden, yet it is believed that the figures represent a fair average of the cost of making *all ore* pig-iron in the regions named.

Middle Pennsylvania.

	Actual cost in 1882.	*Estimated cost in 1884.*
Ore,	$9 37	$7 75
Fuel, coal and coke,	5 02	4 62
Limestone,	1 00	1 00
Labor,	2 35	3 25
Incidentals,	48	
Total cost per ton,	$18 22	$16 62

Harrisburg, Pennsylvania.

	Actual cost in 1882.	*Estimated cost in 1884.*
Ore, 2¼ tons, @ $4 00,	= $9 00	$7 50
Coal, 1½ tons, @ $3 60,	= 5 40	4 50
Limestone,	85	85
Labor,	2 10	3 25
Incidentals,	1 00	
Total cost per ton,	$18 35	$16 10

Lower Susquehanna District.

	Actual cost in 1882.	*Estimated cost in 1884.*
Ore,	$7 60	$7 25
Fuel,	7 00	4 95
Limestone,	56	56
Labor and incidentals,	3 00	3 25
Total cost per ton,	$18 16	$16 01

Lehigh Valley District.

	Actual cost in 1882.	*Estimated cost in 1884.*
Ore,	$9 84	$8 00
Coal,	5 30	5 00
Limestone,	77	77
Labor,	2 33	3 25
Incidentals and repairs,	2 64	
Total cost per ton,	$20 38	$17 02

The following additional *actual cost* has been obtained for the Lehigh region during the past year. This represents the work of a well equipped plant possessing unusual advantages for cheap ore combined with skillful and judicious management; and the cost given is undoubtedly considerably lower than the *average* cost in the Lehigh region during the same period.

Ore,	$7 28
Coal,	5 29
Limestone,	51
Labor,	1 81
Incidentals and repairs,	95
Total cost,	$15 84

Pittsburgh.

	Actual cost in 1882.	*Estimated cost in 1884.*
Ore,* 1¾ tons, @ $6 75,	$11 81	$10 00
Coke,	3 39	3 00
Limestone,	77	77
Labor and incidentals,	2·00	3 25
Total cost per ton,	$17 97	$17 02

Phillipsburg, New Jersey, 1881.

	Actual cost in 1881.	*Estimated cost in 1884.*
Ore,	$9 46	$8 00
Coal,	5 64	5 24
Limestone,	42	42
Labor,	1 59	3 25
Incidentals,	76	
Total cost per ton,	$17 87	$16 91

Any comment upon these comparative estimates would be superfluous. They show conclusively that pig-iron can be made at numerous points along the lines of your railroads to such advantage that—apart from the local demand for it which the development of the country will undoubtedly

* Lake Superior hematite.

make—it can bear long transportation to markets and successfully compete with other localities, and yet leave a handsome profit for capital judiciously managed.

The advantages which the territory traversed by your several lines of railroad offers to the Iron Master may be summed up in a few words: The ores are abundant and generally of good quality; they can be economically mined, for the country in many localities is broken up by numerous ravines affording natural openings for mining operations; most of the deposits are within convenient distance of the railroads—with easy down grades; the water supply, either for washing ore or for manufacturing purposes, is ample and permanent at all seasons; limestone for fluxing purposes exists in unlimited quantities; coke of the finest quality for blast-furnaces can now be obtained at a reasonable cost; and the railroad facilities for reaching markets in every direction are unusually good—thus forming a combination of favorable circumstances rarely equaled.

Respectfully submitted,

ANDREW S. MCCREATH.

INDEX.

Page.

Abbott Iron Company's property and furnace, ... 34–36
Abingdon; ores near, ... 4; 69
Alabama fossil ore; coke, ... 12; 129
Alaska, steamship, ... 119
Alexander, Mr., ... 98,103
Alexander & Neitch's zinc prospect, ... 103
Alexander, Neitch & Roland, ... 98
Alger, Emanuel, ... 23
Allegheny mountains, ... 4,7
Allentown, ... 4
Altoona coal mines, ... 130
Amherst furnace, ore shipped to, ... 45
Arcadia furnace; property, ... 10; 49–51
Ashland, projected railroad connection with, ... 2
Atwood cut, ... 27
Augusta county blast furnaces; iron ores in, ... 10; 9,36-42
Austinville, iron and lead ores near, ... 91,102
Back creek, iron ore near, ... 39
Baltimore, ... 1,32,118
Baltimore and Hampshire coal, ... 120,124
Baltimore and Ohio railroad, ... 1
Barren Springs furnace; zinc and lead prospect, ... 78; 102
Basic process, ores suitable for, ... 135
Bear bank, ... 40,137
Bedford county, iron ores in, ... 9,57,58
Bell branch, coal opened on; tide level, ... 115,127; 115
Bentonville, ore near, ... 19
Berryville, ore near, ... 19
Bertha zinc mine and works, ... 102
Berlin, George W., ... 33
Bessemer ores, ... 137
Bessemer pig-iron, ores suitable for, ... 65–71,137
Bethlehem, ... 4
Beverly furnace, ... 79
Beverly Ore Company's mines, ... 24,25
Big Run creek, ore near, ... 33
Big Reed Island creek, ... 81,82
Billips, Gid., ... 62
Birdeye limestone, ... 8
Blackwell, Charles, ... 120
Blacksburg ores; coals, ... 99; 130
Blacksburg M. and M. Co., ... 130

Page.
Blackband ore, ... 15,16
Black Rock bank, ... 41
Black river limestone, ... 8
Bland county, iron ores in, ... 101
Bland court-house, ... 101
Bleaching powder, manganese ores for, ... 17
Blue mountain, ... 4
Blue ridge, general description of, ... 4
Blue ridge rocks; iron ores, ... 7; 10
Bluestone Coal Company, ... 106
Bluestone river, Flat Top extension runs along, ... 2,106
Bluestone river, tide level, ... 110
Bluestone river, coal lands lying along, ... 2,105
Boiling Springs, ... 10
Bolan cut, ... 27
Bonanza mine, ... 22
Boom furnace; property, ... 78; 82,83
Botetourt county blast furnaces; iron ores in, ... 10; 9,49–56
Boyer, L. S., ... 139
Boyer bank, ... 26
Bristol, ... 2,4,70,72,107
Broad Top coal, analysis of, ... 119
Brough's run, ... 54
Brown Hill furnace; ore bank, ... 78; 87
Brown Hematite ores, different varieties of, ... 14
Brush Mountain iron ores; coal, ... 99; 130
Brushy Mountain, ... 4
Buchanan, ores near; cost of making pig-iron at, ... 49,50; 139
Buchanan and Peaks of Otter turnpike, ores along, ... 49
Buena Vista Furnace property, ... 10,44–47
Buena Vista ore mines, distance from Flat Top coke of, ... 107
Buffalo, ... 31
Buffalo creek, ... 56
Buford bank, ... 57
Bushong Switch, ... 70,72
Calciferous sand-rock formation, ... 8
Cambria Iron Company, manganese ores shipped to, ... 52
Canada, ... 7
Canton, coal samples taken at, ... 118
Carbonate iron ores, ... 15
Carlisle, ... 4
Cardiff coal, analysis of, ... 119
Carnegie Bros. & Co., ... 71
Carter bank, ... 83
Carter—Billips, ... 62
Cash lands, tin ore opened on, ... 134
Cassiterite, ... 134
Caswell Branch, coal opened on, ... 113
Catawba Mountain, ... 12
Catlettsburg, projected railroad connection with, ... 2
Catskill formation, ... 9,13

Page.
Cave Hill furnace, ... 79
Cecil, J. G., ... 80
Cedar creek, ... 84
Cedar Run furnace; ore bank; pig-iron, ... 78; 83; 84
Central, ... 2,107
Chadwell property, ... 90
Chambersburg, ... 4
Champ property, ... 63
Champ—Shephard property, ... 18,19
Chapman, McLanahan, Roher, &, ... 58,59
Chapman ore development, ... 67
Charlestown, ... 1
Chattanooga, ... 3,107,128
Chazy limestone, ... 8
Chesapeake and Ohio railroad, ... 1,13
Chesapeake Bay, ... 2
Chestnut Ridge, ... 98
Chilhowee formation, ... 8
China clay, ... 133
Christiansburg, ... 4,7
Cincinnati group, ... 8
City Point, ... 107
Clark bank, ... 80
Clarke county, iron ores in, ... 18
Clayton's property, ... 60
Clearfield coal; analyses of, ... 107; 118,119
Clinton formation, ... 9
Cloverdale furnace and iron ore, ... 10,55
Cloverdale and Fincastle road, ore near, ... 55
Coal Branch, coal mined on, ... 106,110,111
Coal Tests, report of, ... 120–126
Coe, W. W., ... 99,130
Cold-Short bank, ... 43
Cold Spring creek, ... 71
Conedoguinet creek, ... 4
Conococheague creek, ... 4
Cost of making pig-iron at different points, ... 139–142
Cotopaxi furnace and ore property, ... 10,30–42
Connellsville coking coal, analysis of, ... 119
Connellsville coke, ... 31,126,129
Cowan ore bank, ... 71,137
Cow Ridge, ... 98
Craig county, iron ores in, ... 100
Craig's Creek, ... 99
Cranberry mine, ... 138
Crane Brothers' steam hoist, ... 57
Crane Creek Coal Company, ... 106
Crane Creek, Flat Top Extension runs up, ... 2
Crane Creek, coal opened on; tide level, ... 116,117; 116
Crigger ore bank, ... 97,137
Crimora Manganese mines, ... 36–38

Page
Cripple Creek Extension, description of; mines along, ... 2,3; 74–97
Cripple Creek ores, described and discussed, ... 74–77
Cripple Creek and New River limestone ores, average composition of, 135,136
Cripple Creek and New River blast furnaces; cost of making coke iron, ... 77–78; 140
Crockett bank, ... 72,73,137
Crozer Steel and Iron Co.'s ore mines; blast furnace, . . . 51–55,57,58; 56,57
Cruikshank, Moyer & Co., ... 31
Cumberland coal, analysis of; coal tested, ... 118,119; 120–125
Cumberland County, ... 10
Cumberland Valley Railroad, ... 1
Cumberland Valley; average composition of ores, ... 4; 135
Cundiff banks, ... 58
Curry, H. M., ... 54,71
Danville, ... 31
Delaware river, ... 4
Devonian rocks, ... 8,18,62
Dogwood Hollow bank, ... 43
Donald bank, ... 43
Donovan property, ... 24
Draper mountain, ... 12
Dry Run Creek; trestle, ... 29,33; 22
Eagle furnace; ore banks, ... 78; 91,92
Eastern Pennsylvania, ... 4
Easton, ... 4
East Fork of Simmons' Creek, coal opened on, ... 114
East Liverpool, China clay shipped to, ... 133
East River Mountain, ... 61
East Tennessee, Valley of, ... 4
East Tennessee, Virginia & Georgia Railroad, ... 2,70
Edgar Thompson Steel Company, ... 54
Edith Iron property, ... 57
Elk creek, ... 48
Elmore & Smith, ... 130
Engine House opening, (Buena Vista,) 44
Faulkner Hollow, ... 130
Faulkner property, ... 64
Ferris & Miles, ... 32
Ferromanganese, ... 16
Fire-Brick and China Clay Works, ... 133
Flat Top Coal company, ... 106
Flat Top coal field described; geographical position of; geology of; topography of, ... 105–129; 106; 107; 109,110
Flat Top coal, analyses of; cost of mining, ... 111–119; 127
Flat Top coal and coke, shipments of; market for, ... 126; 128,129
Flat Top coke compared with Connellsville, ... 126
Flat Top Extension, general description of, ... 2,106
Flat Top mountain; tide level of crest, ... 105; 110
Flipping creek, coal opened on, ... 115,116
Fluorspar associated with magnetite, ... 66
Foltz Run, ... 26

Page.
Fontaine, Professor, ... 107,109
Forney property and ore, ... 80,81,137
Fort valley, fossil ore in, ... 13
Fossil ore beds of Pennsylvania, ... 13
Foster's Falls furnace, ... 78
Fox Mountain bank, ... 10,28,30
Francis Mill creek, ... 95,96
Franklin county, ... 10
French Broad river, ... 8
Gale farm, ore on, ... 59
Gap mountain, ore on, ... 100
Garrett Place ore, ... 71,137
Garth, Mr., ... 70
Gaw's Cut, ... 39,40
Gem furnace described; pig-iron made in, ... 31,32; 32
Geological formations, ... 8,9
Geological section along Laurel creek, ... 107,108
Giles county, iron ores in, ... 66,67
Glade ore bank, ... 87
Glenwood furnace and estate, ... 10,47,48
Goethite, ... 14,15
Golleher bank, ... 68,137
Graham, ores near, ... 62,64
Graham bank, ... 83
Graham—Smoot property, ... 64
Grayson turnpike road, zinc prospect near, ... 103
Great Limestone Valley, description of, ... 3
Greenlee mine, ... 47
Greenville station, ore near, ... 40
Greenwich, coal samples taken at, ... 118
Grey opening, ... 69
Guggenheim coal bank, ... 129
Guion steamship "Alaska," 119
Gypsum deposits, ... 104,105
Haerriett mine, ... 21
Hagerstown, northern terminus of S. V. R. R., ... 1
Hammer bank, ... 85
Hardin, Col., ... 134
Harman ore property, ... 64,137
Harman Ridge, ... 64
Harmer & Randle, ... 22
Harper's Ferry, ... 7
Harrisburg; iron shipped to; ore shipped to; cost of making pig-iron at, ... 4; 32; 66; 141
Harrisburg Fire-Brick Works Company, ... 133
Henderson, Giles J., ... 99,130
Hog Trough Valley, zinc prospect in, ... 103
Holston river; south fork of, ... 98; 69,103
Honaker bank, ... 60
Honey Run trestle, ore near, ... 23
Hopper ore development, ... 22

Page.
Hornblende, sometimes mistaken for magnetite, ... 15
Houston, Colonel, ... 58,126
Houston mines, ... 51–54,137
Huddle branch, ... 92
Hudson river; slate, ... 3,4; 8
Hunting Camp Valley, iron ore in, ... 101
Hussey Mountain, iron ore on, ... 95
Ingham station, ore shipped from, ... 24
Inter-conglomerate Coal Measures, ... 109
Iowa, ... 12
Irish creek, tin ore near, ... 134
Iron, cost of making at different points, ... 139,142
Irondale furnace, ... 78
Iron Mountain, ... 4,11,76,94
Iron ores, different varieties of, ... 14–16
Iron ore horizons, general description of, ... 9–13
Ironton, projected railroad connection with, ... 2
Ivanhoe furnace and ore bank, ... 3,78,87–90
Ivanhoe furnace, zinc and lead prospect opposite, ... 102
Jackson & Martin, ... 103
James, Paul, ... 101
James river, ... 4,8
Jennings creek, ... 51
Jeremy's run, ... 23
Jerry's creek, ore near, ... 98
Jones, Thomas, ... 105,130
Johns Mountain, iron ore on, ... 101
Johnson bank, Reed Island creek, ... 82
Johnson (Ripplemead) mine, ... 66,137
Johnson City, ... 107
Kelly bank, ... 42
Kennedy iron tract, ... 40
Kimball bank; station, ... 27; 23
King bank, ... 82
Kittatinny mountain and valley, ... 4
Knoxville; fossil ores near, ... 4,107; 13
Knoxville limestone, ... 8
Lathrop, Mr., ... 107,109,111
Laurel creek, geological section along, ... 107–109
Laurel creek, railroad along; tide level, ... 2,105,106; 110
Layman, Jacob G., ... 55
Lead and zinc ores, ... 12,101–103
Lebanon: valley, ... 4; 4
Lee county, ... 109
Lehigh county; river, ... 10; 4
Lehigh valley, cost of making pig-iron in, ... 141,142
Lehigh valley ores: average yield of, ... 10; 135
LeWarne, Captain, ... 55,57
Lewisburg limestone, ... 9
Lewis run, ores near, ... 35
Lexington branch of Richmond and Allegheny railroad, ... 1

Page.
Lexington turnpike, marl near, ... 47
Leibig, ... 104
Limonite, ... 14,15
Limestone, iron ores in, ... 10,11,65,74,76
Lipscomb station, fire-brick works near, ... 133
Little Reed Island creek, ... 78,81,82
Little Walker's mountain, coal on, ... 131
Loch Laird, ... 1
Locust Grove farm, iron ore on, ... 92
Longdale furnace, ... 13
Lower Helderburg limestone, ... 9,13
Lower Silurian limestones, red hematite and magnetite in, ... 65–71
Lower Susquehanna district, cost of making pig-iron in, ... 141
Low Moor furnace, ... 13
Lowry (Cowan) bank, ... 71
Luray, ... 1
Lynchburg, ... 2,4,8,107
Lynnwood switch, ore near, ... 34
Mack's creek; mountain, ... 11,78,79; 80
Madison creek, ... 85
Magnesian limestone formation; ores of, ... 8; 10
Magnetic iron ores; in the Lower Silurian, ... 15; 65–73
Manassas branch of Virginia Midland railroad, ... 1
Manganese ores; analyses of; shipments of, ... 16; 28,37,54; 38
Manganiferous iron ores; analyses of, ... 17; 27,34,40,42,53,54,80,87
Marion, ... 103
Market for Flat Top coal and coke, ... 128,129
Marksville, ochre near, ... 132
Marl, analysis of, ... 47
Marl branch, ... 47
Martin, David, ... 99
Martins'—See Pulaski.
Martin ore banks, ... 61,100
Martinsburg, ... 4
Maryland, ... 1,3
Massanutton mountain, ... 5,6,8,12,13
Mauch Chunk red shale, ... 9
May's mountain; ore bank, ... 12; 51
McClung bank, ... 43
McDaniel bank, ... 71,137
McDowell county, coal in, ... 105
McLanahan, Rohrer and Chapman, ... 58
Medina sandstone, ... 8
Mercer county, coal in, ... 105,109
Merica bank, ... 27
Meyers, William, ... 130
Middle Pennsylvania; cost of making pig-iron in, ... 4; 141
Mill creek, coal opened on; tide level, ... 112,127; 112
Mill's creek, ... 39
Mill's bank, ... 100
Mill mountain, ores on, ... 58

Page.
Miller bank, ... 35
Millstone grit, ... 9
Milnes, Mr., ... 28,139
Milnes furnace; cost of making pig-iron at, ... 107; 139
Milnes station, ores near, ... 26,30
Mine bank, ... 42
Miscellaneous minerals, ... 131,134
Missouri, ... 72
Mont Alto, ... 10
Montgomery county coals; ores, ... 13,129,130; 99,100
Montgomery Switch, ores near, ... 70
Moore, A. Mason, ... 19
Moore, Captain W. O., ... 92
Mount Torry furnace and ore property, ... 10,38,39
Mount Vernon furnace, ... 34
Mountain bank, ... 48
Mountain Limestone, ... 9
Murray bank, ... 55
Naked Creek, ... 29
Natural Bridge, ... 1,10
Nelson Coal bed, ... 110
New England, ... 11
New Jersey; cost of making pig-iron in, ... 3; 142
New Mine, ... 21
New Orleans, ... 3
New River; zinc and lead near, ... 4,8,11; 102
New River Division described; ores tributary to, ... 2; 61-67
New River blast furnaces, ... 78
New River and Cripple Creek ores described; average composition of, ... 74-79; 135,136
New River Mineral Co.'s property; zinc and lead prospect, ... 87-90; 88
New York, ... 3,7,8,107
Newburg, ... 3,4
Newport, ores and furnace near, ... 68,100
Newton's property, ... 42
Noble furnace; ore property, ... 79; 93-96
Norfolk; shipping docks, ... 2; 107
Norfolk & Western main line; mines along; ores tributary to; blast furnaces, ... 1,2; 56-61; 65-71; 138
Norfolk & Western, New River Division of; Flat Top Extension and projected extension to the Ohio river; Cripple Creek Extension, . . 2
Norma Iron Company's property, ... 93-96
North Carolina, ... 7,8
North Mountain, general description of; rocks of, ... 4,5; 8,12
North River of James, ... 45
Neugan diggings, ... 79
Ochre, ... 132
Ocoee formation, ... 8
Offield property, ... 73
Ohio Central railroad, projected connection with, ... 2
Ohio river, projected railroad line to, ... 2,106

Page.
Ohio valley, ores for the blast furnaces of, ... 77
Old Field ore bank, ... 92
Old Red Sandstone formation, ... 9
One Hundred Mile station, ore near, ... 33
Oneida conglomerate, ... 8
Ores of iron described; manganese, ... 14–16; 16,17
Oriskany sandstone; ores, ... 9; 13
Outburst vein, Noble property, ... 94
Overall, Major; property, ... 131; 10,20,21
Oxford Ochre Company, ... 132
Pack's tunnel mine, ... 67,137
Page county, ores in, ... 10,21–28
Painter ore bank, ... 87
Peak mountain, ... 6,7
Peaks of Otter; turnpike, ore near, ... 4,8; 49,50
Pearisburg, ores near, ... 65,67
Peery, Captain Edward, ... 101
Pennsylvania; fossil ore of, ... 3,10,11; 12
Pennsylvania, cost of making pig-iron in, ... 141,142
Pennsylvania railroad, connection with, ... 1
Perfator, William, ... 130
Peter's gap, ... 2,106,110
Philadelphia, iron shipped to; coal samples taken at, ... 82; 118
Phillipsburg, cost of making pig-iron at, ... 142
Pierce furnace; ore property, ... 78, 84–86,137
Pig-iron, cost of making, at different points, ... 139–142
Pilot Knob ore, ... 72
Pine Grove, ... 10
Pinnacle fork of Guyandotte river, projected railroad line along, . . . 2,106
Pittsburgh, projected railroad connection with; manganese ore shipped to; cost of making pig-iron at, ... 2; 87; 142
Pitchy limonite, mistaken for coal, ... 21
Plaster of Paris, ... 104
Pocahontas village, table of distances from; geological section near, . 107; 108
Pocahontas mines and coal bed; tests of the coal, ... 110; 120–126
Pocono formation; coal beds, ... 9; 13,129–131
Point of Rocks, ... 7
Pollard Cut, ... 50
Pond bank, ... 10
Poplar Camp Mountain, ... 4,11,76,91
Port Republic, ore near, ... 34,35
Porter bank, ... 95
Porter's road, ore along, ... 90
Potomac river, ... 1,4,7,13
Potsdam sandstone formation; ores in, ... 9; 9,20,43
Pottsville Conglomerate, ... 9,107
Poverty Branch, ... 130
Preston ore opening, ... 69,137
Price bank, ... 68,137
Price mountain, coal on, ... 130

Page.
Pulaski; Zinc Works; projected blast furnace at; cost of making iron at, ... 13,107; 102; 138; 140
Pulaski County, iron ores in; coal beds of; blast furnaces of, ... 60, 61,79–82; 13,130; 78
Purgatory mountain; iron property, ... 12; 51
Pyrolusite, ... 16
Pyroxene, ... 15
Quinnimont coal group, ... 107,109
Radford furnace and ore property, ... 78,79
Raines bank, ... 35
Raleigh County, coal in, ... 105,109
Ravencliff furnace, ... 78
Razor bank, ... 98
Reading, ... 4
Red hematite ores, different varieties of, ... 14
Red hematite ores, Lower Silurian, ... 65–73
Red hematite, so called Blue Ridge specular ore, ... 9,20,39,48,51,58
Reed creek, Stony Fork of, ... 131
Reed Island creek, ... 81,102
Reed Island Iron company's furnace; ore property, ... 78; 81,82
Rich Hill (Forney) property, ... 80,81,137
Richmond; market for Flat Top coal, ... 107; 128
Richmond and Allegheny railroad, ... 1
Richmond and Danville railroad, ... 128
Rileyville, ore near, ... 22
Ripplemead mines, ... 66,137
Riverton, ... 1
Roanoke, southern terminus of S. V. R. R.; distant from Pocahontas; blast furnace at; cost of making pig-iron at, ... 1; 107; 56; 139
Robertson Bros., tin prospect, ... 134
Robinson, James, ore outcrop, ... 99,137
Rock Castle, projected railroad line to, ... 2
Rocky mountains, ... 7
Rockbridge county, blast furnaces of; iron ores in; tin ore of, . . . 10; 9,42–48; 134
Rockingham county, blast furnaces of; iron ores in, ... 10; 28–36
Rogers, Prof. William B., ... 8
Rogers, Prof. H. D., ... 8
Rohrer Iron company's property, ... 58,59
Rohrer & Chapman, ... 59
Rose property, ... 63,137
Round mountain, ore on, ... 101
Roy, G. N., ... 21
Rudisill property, ... 19,20
Rust, Breckenridge, ore property, ... 23
Rye valley, ... 98
Salina ore bank, ... 20
Saltville, ... 13,104
Salt works; plaster, ... 13; 105
Samson's property, ... 90,91
Sands, Joseph H., ... 120

Page.
Sanders ore bank, ... 86
Sanderson, R. P. C., coal tests, ... 120
Saucon zinc mine, ... 12
Schuylkill river, ... 4
Scott county, ... 109
Seaboard and Roanoke railroad, ... 128
Seral Conglomerate, ... 107
Seven Mile Ford station, ... 98
Sharp bank, ... 70,71,137
Shawangunk mountain, ... 4
Shenandoah river, ... 4,6
Shenandoah junction, ... 1
Shenandoah Valley, general description of; iron ores along, ... 4; 9-12
Shenandoah Valley railroad described; mines along; average composition of the ores; blast furnace sites, ... 1,2; 17-56; 135; 138
Shenandoah Iron Company's property; blast furnaces; forge; cost of making iron; character of iron, ... 25-32; 30-32; 32; 139; 31,32
Shephard, Champ, property, ... 18,19,137
Shepherdstown, ... 1
Sherando station, ores near, ... 38
Shockley, Wesley, ... 85
Simmons creek, coal opened on; tide level, ... 113,114,127; 114
Sinking creek; furnace property, ... 68; 68,100
Skillern mountain, red hematite on, ... 48
Smith coal bank, ... 130
Smith ore bank, ... 10,26
Smith & Slusser, ... 129
Smoky Mountains, ... 4
Smyth county, iron ores in; gypsum; zinc ore, ... 98; 104; 103
South Mountain, general description of; rocks of, ... 4; 7,9
South river of James, ... 41,42
South-west Virginia, iron ores of, ... 11,74
South-West Virginia Improvement Company's coal lands and mines; iron ore mines, ... 106,107,110-112; 65-67
Specular ore of the Blue ridge, (see red hematite,) 9
Speedwell furnace, ... 3,79,96
Spiegel, ores required for, &c., ... 16
Spring creek, ... 70
Springville, ores near, ... 63,64
St. Albans, projected railroad connection with, ... 2
Staunton, ... 1,4,7
Stevenson, Professor, ... 107,109
Stokes & Parish, ... 31
Stony Fork of Reed creek, coal on, ... 131
Stony run (Boyer) bank, ... 26
Stuart's draft station, ores near, ... 40
Sub-carboniferous coals, ... 129-131
Sullivan county, Tenn., ores of, ... 70-73
Summary of results, ... 134
Susquehanna river, ... 4
Susquehanna valley, ores for; cost of making iron in, ... 24; 141

Page.
Swatara creek, ... 4
Taylor's ridges, ores on, ... 61
Tazewell county, ores in; coal in, ... 61-65; 105,107,109
Tennessee; river; iron ores, ... 3,7,8; 3,4; 12,70-73
Thomas bank, ... 73,137
Timber for mining purposes, ... 127
Tin ore developments in the Blue ridge, ... 134
Tipton furnace, ... 78
Tolliver branch of Crane creek, coal opened on, ... 116
Tom's creek coal beds, ... 130
Traister Find, ... 21
Trenton, zinc ore shipped to, ... 102
Trenton Limestone, ... 8
Troutville, ore near, ... 55
Turgite, ... 14,15
Turk's Gap of the Blue Ridge, manganese ore at, ... 36
Umber, ... 131
Upland mines of Crozer Steel and Iron Co., ... 58
Upper Helderberg Limestone formation, ... 9
Utica slate formation, ... 8
Valley Branch of B. & O. R. R., ... 1
Van Liew, ... 87,137
Vesuvius furnace and ore property, ... 10,42-44
Virginia Manganese Company's mine, ... 36
Virginia Midland Railroad, ... 2,128
Walker's Creek, ... 67
Walker's mountain (Little), coal beds on, ... 131
Walkill Valley, ... 4
Walton furnace and ore bank, ... 78,86,87
Warren county, ores in, ... 19,21
Washington county, iron ores in; plaster, ... 68-70; 104,105
Watery Branch, ore near, ... 24
Waynesboro Junction, ... 1
Weaver banks, ... 34
Welch, Capt. I. A., ... 112,113
West India coal trade, ... 107
West Fork of Flipping Creek, coal opened on, ... 115,116
West Virginia; coals of, ... 1,7; 105
Western Maryland Railroad, ... 1
Westmoreland coal, analysis of, ... 119
Weyer's Cave station, ores near, ... 35
Wheeling, projected railroad connection with, ... 2
White Rock furnace; ore bank, ... 79; 97
Whitwell Hot Blast Stoves, ... 32,57
Widemouth Creek, ... 105
Wikel, P. G., ... 133
Williams, A. J., ... 98
Wilmer & Jackson's property, ... 33
Winchester; valley, ... 4
Windmill gap, ... 116
Wise county, ... 109

Page.
Wisconsin, ... 12
Witherow & Gordon, ... 56
Wolf run, ... 27
Wyoming county, coal in, ... 105
Wythe county, iron ores of; zinc and lead ores of; coal beds of; blast furnaces of, ... 11,74,82-97; 12,102,103; 13,131; 78,79
Wythe furnace, ... 79
Wythe Lead and Zinc Co.'s property, iron ores; zinc and lead ores, . 91; 102
Wytheville, ... 4,131
Young's run, ore near, ... 27
Zinc and lead ores, ... 101-103
Zinc Works at Pulaski, ... 13,102